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THE POLLUTION OF THE PASSAIC RIVER AT NEWark, N. J., has at last aroused the manufacturing and commercial interests of the city to such an extent that the Board of Trade has taken up the matter with unusual vigor. In response to inquiries by the Board a number of merchants and manufacturers on the river front have written letters stating that their interests are being seriously injured by sewage pollution. The Clark Thread Co. took up the sumject at length. It stated that it has 3,000 employees working and living near the river whose health, and therefore their efficiency, is liable to be injured by the condition of the stream. Last summer there was an unusual amount of sickness among those of the employees of the company working close by the river, which the company attributed "to the noxious vapors from the river." Besides this, the company has "had to give up the use of it (river water) for lavatories, sinks, closets and floor washing on account of its extreme foulness." It is to be hoped that this agitation will be continued until the State Legislature provides some effective means of remedying the nuisance, which is due to the use of the river as an open sewer all the way from Paterson to the Newark Bay.

PRIVATE OWNERSHIP OF A SEWERAGE SYSTEM at Baltimore, Md., is again under discussion. The mayor has placed himself on record as against the issuance of bonds for a sanitary sewerage system during his administration. It is reported that the Maryland Construction & Contracting Co. will seek amendments to its charter, from the next legislature, permitting it to build sewers under a franchise. The company proposed to do this a while ago, but investigation showed that its charter did not permit such action.

THE EXECUTIVE COMMITTEE OF THE CALIFORnia Water & Forest Association has decided to raise $10,000 by subscription to make available a similar amount of the funds of the U. S. Geological Survey for hydrographic work in California. It will also co-operate with the U. S. Department of Agriculture in its investigations of irrigation. At the meeting of the committee, held a short time ago, Messrs. Elwood Mead, M. Am. Soc. C. E., of the Department of Agriculture, and J. B. Lippincott, Hydrographer of the U. S. Geological Survey, were present to aid the committee in formulating its plans.

THE PORT ROYAL TIMBER DAY-DOCK, built a few years ago at a cost of over $500,000, is practically a wreck and unserviceable, according to late investigations ordered by the Navy Department. The defects seem to be due to faulty construction and design, and to the teredo navalis. It is said that Rear Admiral Endicott, Chief of the Bureau of Docks and Yards, will recommend its replacement by a stone and concrete dock of large dimensions.

THE SUBMARINE TORPEDO-BOAT "HOLLAND" has made the trip from Elizabethport, N. J., to Washington, D. C., in eight days under tow by the yacht "Josephine." The trip was made through the Delaware & Raritan Canal to Bordentown on the Delaware River, pontoons being here used to lighten the "Holland" 2 ft. The pontoons were discarded at Bordentown, and the boats proceeded down the Delaware to the entrance of the Chesapeake & Delaware Canal; through this to Elk Neck, and thence to Annapolis and Washington. The little craft proved perfectly seaworthy. She will be again tested over a measured course on the Potomac, 10 miles below Washington.

THE CELLULOSE PACKING in the U. S. Cruiser "Olympia," in some of the compartments, has been converted into a mass resembling black mud, and has lost its life. It has become offensive in odor and a menace to the health of the ship's crew, and is utterly worthless for obdurating purposes. The cause seems to be the admission of water to these compartments. Another result of service in tropical waters is that some of the woodwork in the ship has been eaten up by a species of "worm," leaving the interior wood a mass of solid rejecta, as fragile as chalk.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred at Pomona, Cal., on the Southern Pacific R. R., on Dec. 24. Five persons were killed, a number were injured and the train was completely demolished.—In a head-or collision between two freight trains on the Northern Pacific Ry., near Drummond, Mont., Dec. 25, five men were killed. The accident was caused by one of the trains running past the designated meeting point.

A MINE EXPLOSION at Brownsville, Pa., on Dec. 23, resulted in the death of an unknown number of miners, estimated between 30 and 40. It is said that there was insufficient ventilation and that open lights were used.

A LANDSLIP AT AMALFI, on the Gulf of Salerno, Italy, on Dec. 22, carried away a great mass of earth and rock upon which stood the Cappuccini Hotel, and also swept away the old Capuchin Monastery, founded in 1212, the Hotel Santa Calerina and several villas. The debris crushed four vessels and destroyed the crews. At last accounts the exact number of people killed was not known. The rock rose abruptly from the sea to a height of 230 ft., and portions of it were undermined by the sea and thrown down in the 12th century.

GRADE CROSSINGS IN WASHINGTON, on the Baltimore & Potomac R. R., are the subject of a bill introduced into Congress by Senator McMillan. This bill provides for eliminating certain grade crossings on this road and divides the cost as follows: The railway company to pay all costs of relocation and elevation and depression of tracks within the limits of its right of way; the other expenses arising from the change in grade, in approaches, etc., are to be paid equally by the United States and the District of Columbia. The bill is very minute in its provisions. The same bill requires the B. & P. R. R. Co. to remove the present Long Bridge across the Potomac and to build within four years on practically the same line a new double track railway bridge on plans approved by the Secretary of War. The Secretary of War would also be required to have built within two years a new passenger bridge, above the site of the present Long Bridge, and provided with a draw span.

THE PROPOSED BERLIN UNDERGROUND RAILway, now before the Municipal Council for approval, would cost about $40,000,000, and includes inner and outer belt lines and two cross lines. A tunnel line under the Spree has just been opened connecting Berlin with Treptow.

TEN MORE LOCOMOTIVES for the State Railways of France follow the satisfactory test of the first lot made by the Baldwin Locomotive Works. The last order is for passenger engines of the type used on the Philadelphia & Reading Railway route to Atlantic City, with 84-in. drivers.

THE CEMENT MINES of the New York & Rosendale Cement Works, at Rosendale, N. Y., caved in, in part, on Dec. 19. The accident was due to a land-slip; and the engine and boiler house and some other buildings were carried away. No lives were lost.

THE STREET RAILWAYS OF HAVANA, Cuba, have been consolidated under the name of the Havana Electric Ry. Co., by a compromise arrived at in the litigation which began about a year ago. In December, 1898, a group of capitalists, comprising the International Bank of Paris, Hanson Brothers, of Montreal, and Col. G. B. M. Harvey and F. S. Pearson, of New York, known as the "Harvey Syndicate," acquired all of the existing railway properties. There was in existence at the time one other concession, covering about twelve miles of streets, the title to which was claimed by the American Indies Co. The Harvey Syndicate also claimed to own the true title to this concession. Litigation was begun by the two parties and has been continued through the year without promise of adjustment for some time to come. In view of this state of affairs, Col. Harvey, on behalf of his company, began negotiations to bring about a settlement, which was finally effected by complete consolidation yesterday. Under the terms of the arrangement the Havana Electric Railway Co. acquires all the rights and shares of stock of the Havana Traction Co., to which the American Indies Co.'s claims had been assigned, and the owners of the Havana Traction Co. become part of the Havana Electric Ry. Co. The electric company reimburses the owners of the traction company for their expenditures and turns over to them a certain proportion of interest in the united company. Work was begun by the electric company several months ago, and it is now expected that a complete system of electric traction will be in operation by June 1. The board of directors of the Havana Electric Railway Co. is as follows: President, Edwin Hanson; Vice-Presidents, William L. Bull and R. A. C. Smith; Secretary and Treasurer, Arnold Marcus. Directors, in addition to those above named, are: P. A. B. Widener, Thomas F. Ryan, Sir William C. Van Horne, William McKenzie, Frederic Nichols, H. M. Perkins, Thomas P. Fowler, E. H. Andron, William M. Doull, N. Gelats, and G. B. M. Harvey. The capitalization of the company remains unchanged, namely, $5,000,000 of preferred stock, $5,000,000 of common stock, and the first mortgage representing $5,000,000 of 5% 50-year bonds.

THE THIRD ELECTRIC UNDERGROUND RAILWAY in London is rapidly approaching completion. The first road is the City and South London, over six miles long, and opened in 1890. It connects Moorgate Station, in the city, with Stockwell, south of the Thames. The second is the Waterloo and London, also passing under the Thames, and only 1½ miles long, connecting the Waterloo Station with the Bank of England neighborhood. The third is the Central London, projected in 1890 and commenced in 1896. It runs from the Liverpool Station, in the city of London, to Shepherd's Bush, cutting in two the great oval made by the Metropolitan and District belt underground roads. It is built in a double tunnel lying form 60 to 100 ft. below the street level. Each tunnel has a diameter of 11½ ft. and is constructed of iron; at stations this width is 21 ft. and the station patforms are 325 ft. long. The power house will be at the Shepherd's Bush terminal and the third-rail system will be used to convey the electric current. The run between terminals is to be made in 25 minutes, instead of 1¼ hours by omnibus, as at present. A fourth electric road is under construction, passing from Waterloo Station, and under the Thames, to Baker St. Station on the old underground road. It will be over two miles long.

THE BATTERY PARK LOOP ON THE MANHATTAN Elevated is being discussed by that company and the New York Park Department, under the demands of the latter for the removal of the railway structure from the park. Vice-President and General Manager Alfred Skitt has offered several plans for consideration for change of route. One plan provides for replacing the present structure by a skeleton truss-girder, more open than the present box-girder, and thus obstructing less light; another plan provides for a similar structure but slightly overlapping the park lawns, but entirely covering the marginal path; the third calls for the building of the road along Battery Place and down State and Whitehall streets, touching the park only at the turn into Whitehall St.; the fourth calls for a road through Battery Place, across Bowling Green, in front of the new Custom House site, and down Whitehall St. in front of the Produce Exchange. In the traffic diagrams submitted it is shown that the business at South Ferry is the largest on the road, the passenger traffic footing up 7,799,985 per year. The City Hall station is next, with 7,674,707; the several other stations of large traffic only amount to about half of the South Ferry business.

PLANS FOR A 20-STORY BUILDING were filed with the New York Building Department on Dec. 22. The new building is to be located at Exchange Place and Broad St., in New York, and will front 236 ft. on Exchange Place and 106 ft. on Broad St., and will have an L 50 × 100 ft. The estimated cost is $4,000,000. The plans were filed one day previous to the taking effect of the new building code, in order to obtain the advantages of the old code. Altogether, plans for buildings aggregating in cost $10,593,400 were filed on the same date for the same reason.

THE AMERICAN PIG-IRON OUTPUT FOR 1900 is being figured upon by the Pittsburg correspondent of the New York "Journal of Commerce." On Dec. 1 the blast furnaces in operation had a weekly capacity of a little less than 290,000 tons of pig iron, or 15,000,000 tons per year. Last year the output was nearly 12,000,000, and this year it will be close to 13,500,000 tons. Much of this iron has been exported; and the largest exporter is the Tennessee Coal & Iron Co., with its 12 to 15 furnaces in Alabama and Tennessee, which sent more than half its product abroad. The Carnegie Steel Co. alone makes from 180,000 to 190,000 tons of pig iron every month; but with the two new furnaces now being erected at Rankin it will largely exceed this, as each of them will have a daily capacity of 700 tons. The Federal Steel Co. turns out from 150,000 to 160,000 tons per month. It is predicted that the cost of making pig iron will advance to $15 to $16 per ton next year for Bessemer iron, against a cost of $10 this year. Old range ores that cost last year $2.90 per ton at lower lake ports will cost $5.50 in 1900, and coke has advanced from $1.50 to $2.75 per ton; limestone and labor are also higher. The present price of Bessemer pig at the furnace is $25 per ton for the first six months of 1900, and, according to the sales already made, this price will probably be maintained for that period.

COMPLETING THE ABANDONED AQUEDUCT TUNNEL AT WASHINGTON, D. C.

After having been abandoned for about ten years, the work of completing the Washington aqueduct tunnel was resumed by the U. S. Government in 1898. Work on the tunnel was begun originally in 1883, or at least the contract with Beckwith & Quackenbush, was signed on Oct. 29 of that year. After the work had proceeded for about five years it was abandoned on account of faulty construction. A joint congressional committee made an exhaustive report on the condition of the tunnel in 1889, which included a report by a board of experts composed of Messrs. Jos. M. Wilson, Henry Flad and Frederic Graff, all Members of the American Society of Civil Engineers. Abstracts of this report, which was adverse to completing the tunnel, were given in our issues of May 4 and 11, 1889. Early in 1896 another report, in favor of completing the tunnel, was made by W. L. Marshall, Major, and Jas. L. Lusk, Captain, Corps of Engineers, U. S. A.; A. Fteley and Desmond FitzGerald, M's. Am. Soc. C. E.; Capt. D. D. Gaillard, Corps of Engineers, U. S. A., signing the report as recorder. This report was abstracted in our issue of Feb. 20, 1896. It was approved by General Craighill, Chief of Engineers, U. S. A., and later on Congress authorized the carrying out of its recommendations.

The tunnel is 20,715 ft. long, and is at an average depth of 150 ft. below the surface. It is designed to convey water, with a minimum loss of head, from the old reservoir at the end of the original Washington aqueduct to a new reservoir in the city. The difficulties of the problem, on finding that the tunnel lining itself was defective, and the backing much of it faulty or omitted altogether, were greatly increased by the fact that the head of water in the tunnel will range from 75 to 175 ft., giving a corresponding internal pressure of 32 to 76 lbs. per sq. in.

The tunnel was driven through rock, which was quite differently characterized by the two boards of experts just named. The first board thought that much of the rock was subject to rapid decomposition, but the second board, with the great advantage of judging after a lapse of seven or eight years, "found the rock, with but few exceptions, to be sound, strong and hard." Besides this, rock from the roof of the bore, although practically unsupported, had fallen only "in two or three places, and to an amount which we consider trivial." One of the principal reasons given by the first board against completing the tunnel was the danger from leakage through the brick lining of the tunnel. The heavy internal pressure, it thought, might result in outward percolation which would soften the earth above and possibly result in damage to property. On the other hand, infiltration of polluted water might occur at times. The second board took an altogether different view of the matter. It thought that the tunnel could be made reasonably secure against outward leakage, and that for the most part the ground water level was so near the hydraulic grade line of the tunnel as to make small the chances of leakage inward.

The methods being employed to complete the tunnel and guard against all dangerous contingencies will be better understood by stating briefly the character of the original work. The lining, according to the report of the first board of experts, consisted of side-walls of brick or stone, and a semicircular brick arch. Only a little over a third of the portion lined when the work was abandoned had an invert. The various linings measured as follows, in lin. ft. of tunnel:

Rubble masonry side walls, no invert, rubble masonry back-filling	5,929.80
Brick side walls, no invert, rubble masonry back-filling	1,270.50
Brick side walls, brick invert, rubble masonry, back-filling	5,849.14
Brick side walls, brick invert, dry stone back-filling	1,717.56
Total	14,767.56
Unlined	5,929.30
Total length of tunnel	20,696.30

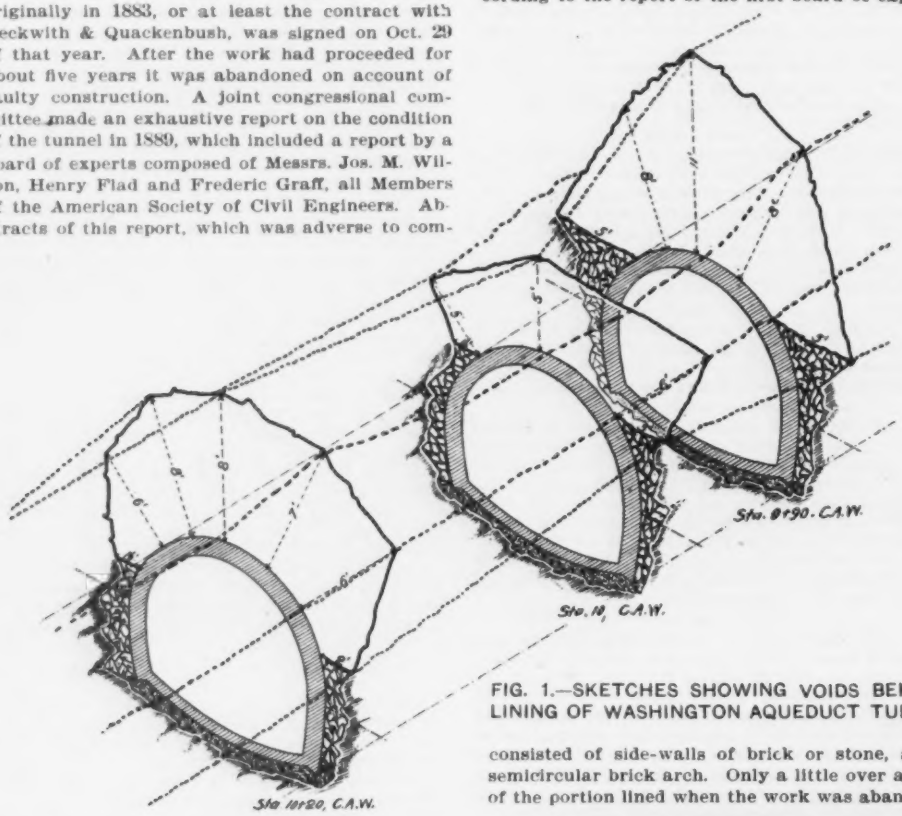

FIG. 1.—SKETCHES SHOWING VOIDS BEHIND LINING OF WASHINGTON AQUEDUCT TUNNEL.

Generally, the arch where on rubble side-walls consisted of two rings of brick, but in some places where the rock was bad, there were three or four rings. The brick lining ranged all the way from good to very poor. The rubble masonry side-walls, the report of the first board states, were good, so far as exposed. The arch backing seems to have been the worst part of the whole job. For the first three years of the work the contract called for solid dry stone packing only. A supplemental contract, dated Oct. 18, 1886, provided for "rubble laid in cement mortar." Hardly any of the dry packing, and none of that supposed to be in mortar, complied with the specifications, and in many places there were voids, some of great extent. The size of some of the larger voids, which are far from being the worst, is indicated by the sketch, Fig. 1, which is a portion of more extensive sketches given in the report on "Increasing the Water Supply of Washington, D. C.," for the year ending June 30, 1899. A large void, filled or partly filled, with stone and timber, is shown by Fig. 2. All the illustrations to this article are also from the report mentioned, or from some of the negatives used in preparing illustrations for that report.

The cross-sectional area of the tunnel was designed to be 76.34 sq. ft. for the lined, and 82.5 sq. ft. for the unlined portion. The second board of experts estimated that the tunnel would have a carrying capacity, with 2 ft. difference between the reservoir levels at each end, equal to nine 4-ft. mains, or more than three 6-ft. mains of the same length.

In the main the work of repairing and completing the tunnel is being carried out in accordance with the following recommendations of the board of experts:

(1) Lining the unlined portion of the tunnel with brick masonry, including invert, and backing same with rubble masonry or concrete.
(2) Constructing an invert in portions of lined tunnel where none was originally built.
(3) Repairing the defective lining already built by removing the timber and loose stone backing and replacing it with rubble masonry or concrete, or grouting where necessary.

FIG. 2.—IMPROPER BACKING TO WASHINGTON AQUEDUCT TUNNEL.
(The man shown in the view is standing on the arch of the tunnel.)

(4) Arranging the drainage of the tunnel west of Rock Creek shaft so that all drainage may be collected at the Rock Creek shaft sump.
(5) Lining the portion of the tunnel in the vicinity of Rock Creek shaft with iron, finished on the interior with brick masonry.
(6) Filling the voids in backing, where dry rubble was used, by grouting same.
(7) Constructing the necessary accessories, including gatehouses, blow-off at Rock Creek, air shafts, etc.

Instead of finishing the iron lining with brick, concrete is being used.

The remainder of this article is based on notes taken by a member of the editorial staff of this

journal, while on a recent visit to the work, in company with Mr. R. C. Smead, Assistant Engineer, and through the courtesy of A. M. Miller, Lieut.-Col., Corps of Engineers, U. S. A., Engineer-in-Charge of the Maintenance and Repair of the Washington Aqueduct. The notes are supplemented by facts drawn from Col. Miller's report for the year ending June 30, 1899, forming Appendix

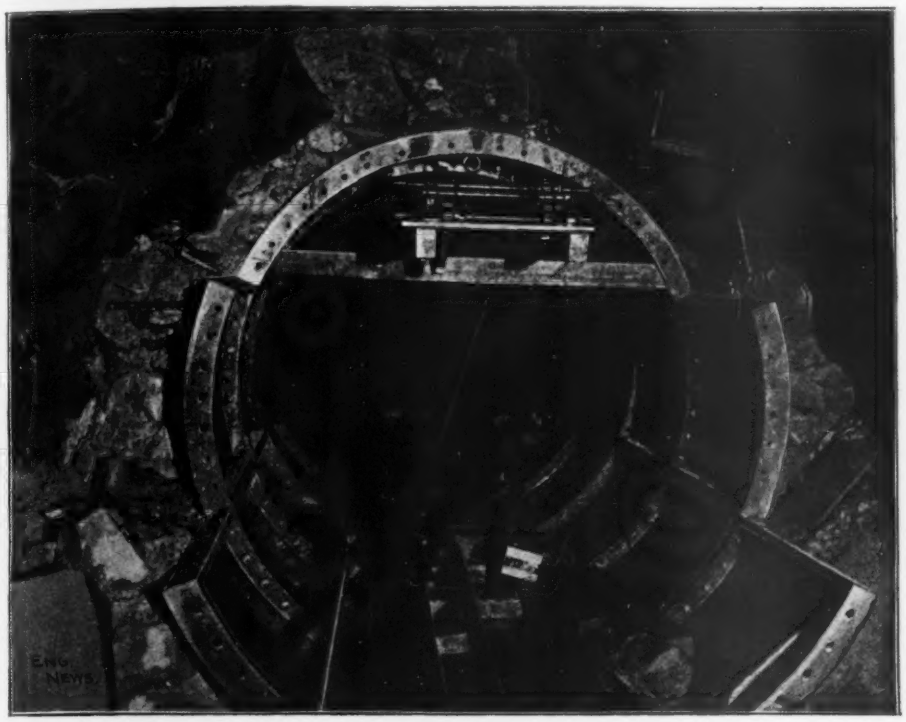

FIG. 3.—CAST-IRON LINING TO TUNNEL BENEATH ROCK CREEK.

BBB, to the annual report of the Chief of Engineers, Brig. Gen. John M. Wilson.

About 500 ft. of the tunnel at Rock Creek is being lined with 1½-in. cast-iron plates, 4 ft. long, eight to the ring, flanged and bolted all the way around, as shown by Fig. 3. The bolts are 1 in. in diameter,, about 5½ ins. c. to c., circumferentially, and about 3 ins. longitudinally. They are being furnished for 4.15 cts, each by Bartlett, Hayward & Co., of Baltimore. The flanges are of the same thickness as the plates, 1½ ins., but are 3½ ins. deep. The rings will be lined with concrete, flush with the flanges, and the surface of the concrete plastered with Portland cement mortar. The iron lining will have a clear diameter of 9 ft.

This iron lining was made necessary by a great leak into the tunnel from Rock Creek, the bed of which is about 39 ft. above the top of the iron ring. The water poured through the tunnel, according to Col. Miller's report, "principally in one large stream, falling clear of the sides of the tunnel, and amounting to about 425,000 gallons per diem," which was nearly doubled at high stages of the creek.

The iron lining is all being backed with solid rubble masonry, except directly at the leak. Here it was necessary to use dry rubble, leaving weep holes. Through these holes grout was forced,. later on, under a pressure of 80 to 90 lbs. The internal pressure on the lining will be about 70 lbs. The grouting here is 1 to 1 Portland cement.

Most of the original work had no invert, but one is now being put in wherever previously omitted. It consists of one ring of brick, on concrete. The old side-walls are being underpinned where necessary, many places being found where these walls rest on only 2 ins. of concrete, placed on a soft or crumbly base.

The unlined portion of the tunnel is being lined with brick, throughout. All cavities back of the old lining large enough to admit a man are being filled with rubble masonry. Smaller voids will be grouted through holes in the brick ring at about 10-ft. intervals, longitudinally, there being four holes in the ring, staggered somewhat. On one stretch of 2,000 ft. of tunnel 2,300 bbls. of cement were used in grouting.

Cumberland cement, 1 to 1, is being used for the grouting, except back of the iron lining, and the same kind of cement is being used generally throughout the work. The concrete for the invert is 1, 2, and 5, and the mortar for the brick work is 1 to 2.

To make sure of the efficiency of grouting an interesting experiment was carried out, which is described as follows in Col. Miller's report:

A model was built 20 ft. long to represent dry stone packing of the tunnel. Timber lagging represented the extrados of the brick lining and also the roof and sides of the rock excavation for the tunnel. Grout, consisting of one part hydraulic cement and two of sand, with water enough to render the mixture of proper fluidity to pass the grouting pump, was pumped into the dry rubble packing of the model through auger holes bored in the interior. The cubic contents of the dry rubble was 67 yds., and the voids by rough measurement in water amounted to 50% or 33½ cu. yds.

The grout was applied until the voids were filled, as indicated by overflow. There were 75 bbls. of cement, 150 bbls. of sand, and the proper proportion of water used. The experiment was made in rather unfavorable weather, December, 1898, and during the pumping the thermometer fell below the freezing point. The lagging was stripped from the structure March 1, and the voids were found completely filled, the structure standing perfectly as a monolith. Photographs showing the result of this experiment are submitted with this report. The conclusion from the experiment is that the grouting can be satisfactorily accomplished.

One of the photographs mentioned in the quotation is reproduced herewith as Fig. 4.

The bottom of the tunnel, west of Rock Creek, is being lowered for 3,427 ft., the excavation ranging from 8 ft. to 0, in order to provide drainage for a part of the tunnel, thus saving one of four sets of drainage pumps originally proposed. The side-walls, throughout this portion, are being carried down to the new bottom. The second board suggested a brick channel, beneath the tunnel, for drainage here, but the method being carried out was considered simpler than building a brick channel in a rock trench.

When the new lining is all completed the whole interior of the tunnel will be given two wash coats of Portland cement. All the work on the tunnel is being done by the day, in order to avoid danger of a repetition of scamping tricks, but the material is being purchased through competitive bids, as far as practicable. The men work in three shifts, where feasible, to keep the work going all the time.

The tunnel is lighted by acetylene gas, made by generators of the Troubetzykoy system, from the Mechanical Engineering Construction Co., 63 Fifth Ave., New York city. A 300-light and a 60-light machine were bought. The larger machine lighted two miles of tunnel satisfactorily, through a main pipe 2 ins. in maximum diameter, with cocks for burners at 30-ft. intervals. By means of rubber tubing the lights may be shifted about as desired, giving good results in the cavities back of the lining, as well as elsewhere. A test of the larger machine indicated that 300 lights cost only 14.5 cts. each per 24 hours.

CHEMICAL PRECIPITATION AND RAPID FILTRATION OF SEWAGE AT MADISON, WIS.

The city of Madison, Wis., with a population of about 18,000, has been wrestling with the sewage disposal problem for several years. A system of sewerage was put in operation in 1886, discharging the crude sewage into Mendota and Monona

FIG. 4.—EXPERIMENTAL DRY RUBBLE ARCH, GROUTED WITH CEMENT.

lakes, with areas of 15 and 6 sq. miles, respectively. On Nov. 18, 1890, Mr. McClellan Dodge, then and now city engineer of Madison, sent a description of the sewerage system to this journal. He

stated that up to that time, the sewers then having been in operation about four years, no complaints of sewage pollution had been made, "except perhaps an increased plant growth" in the lakes. There were then about nine miles of 12 to 6-in. sewers in use, and about 400 house connections. The sewers were on the separate plan, except that some roof water "usually one building at end of sewer" (probably laterals) was discharged into the system. There were no manholes in use in 1890. The main changes in the collecting system since 1890, aside from the diversion of sewage from the lake, Mr. Dodge has informed us under date of Nov. 1, 1899, are ah follows:

> The collecting system, excluding the intercepting sewer, now consists of 21¾ miles of sewers, ranging from 6 to 15 ins. in diameter; 50 manholes and 30 flush tanks. The flush tanks are not used except for freeing a sewer which shows signs of clogging, and several times a year for general cleaning purposes. There are about 1,100 connections with the sewers at present, but as all of the sewers are not now connected with the disposal works I cannot give you the population contributing to the works. (Later, Nov. 17): I have since investigated and find that there were at least 850 connections from which the sewage reached the disposal plant during the tests mentioned (about Oct. 1.—Ed.).

With the natural increase in both the population of the city and the number of sewer connections, there began to be complaints regarding the pollution of the lake. From 1893 to 1898 numerous plans for abating the pollution were formulated. The original sewerage system, it may be said here, was built with Mr. John Nader, now of Madison, as engineer, and Mr. Saml. M. Gray, M. Am. Soc. C. E., as consulting engineer. Mr. Gray recommended at the start, that the sewage be treated by chemical precipitation. Late in 1893, Mr. Nader and Mr. Dodge, together with other engineers in the city, were invited to submit plans for diverting the sewage from the lakes and treating it by chemical precipitation. In August, 1894, Col. Geo. E. Waring, Jr., made a report on the subject, in which he recommended the use of a certain tract of land for broad irrigation. In October, 1895, the city council adopted a plan for chemical precipitation, with sand filtration of the tank effluent, in accordance with the recommendations of a special committee, the plan having been proposed by Messrs. Dodge and Nader. The estimated amount of sewage to be treated "for a long time to come" was placed at about 300,000 gallons. Four 100,000-gallon precipitation tanks, and about four acres of filter beds were proposed. The estimated cost of the disposal works was $29,075, and of the intercepting sewers, $27,499. The annual operating expenses of the disposal works were placed at $3,000 to $3,500. Although the mayor approved the resolution of the council adopting this plan, and a date was set for hearing objections, nothing further ever came of it.

In March, 1897, the city council appointed still another committee on sewage disposal, instructing this one to report on land disposal. The committee reported in July, 1897, rejecting broad irrigation, or a combination of it, and intermittent filtration, and directing its attention to filtration alone. After careful explorations of the country about Madison, borings and examinations of soils, it was found that suitable land was very limited. The best comprised three tracts, aggregating about 25 to 30 acres, at $100 to $200 an acre, and the cost of about 13,000 ft. of outfall pipe sewer, the receiving tank, pumping station, and preparation of 15 acres of land was estimated at $55,000 to $60,000. This proposition was described in our issue of Sept. 2, 1897. It was never carried out. The committee, of which Mr. Dodge was a member, appears to have merely followed the instruction of the council to report on land disposal, and expressed no opinion as to the relative merits of this and the plans previously submitted.

Later on, the American Sanitary Engineering Co., of Detroit, Mich., presented plans for chemical precipitation tanks and filter beds. Early in 1898 these plans were adopted by the city, after some modifications on its part, designed to reduce the cost. The changes, according to one of the city officials, "consisted simply in cutting out unnecessary exterior walls and reducing the size somewhat, with slight changes in the elevations of different parts, etc." The city also insisted on putting in the machinery equipment, leaving the company to put in only the settling tanks and filter beds. Construction was commenced in June, 1898, and was to have been completed by November, but owing to delay (largely due to the work on the city's outfall sewer) the plant was not put into operation until last spring, and has only been in continuous operation since June, 1899.

The contract provides that the company shall operate the plant for three months, and the city for nine months. The total cost, according to the complete original plans, was to be about $50,000, but the plant as built has cost about $48,000, without buildings. Of this amount, the company's work on the tanks and filters represent $37,200, of which $12,200 has been reserved by the city until the close of the first year of operation. The balance will then be paid, provided a committee of three, including the city engineer, decides that the plant has fulfilled the contract requirements. The company also gave a bond for $25,000 for the proper fulfilment of the contract.

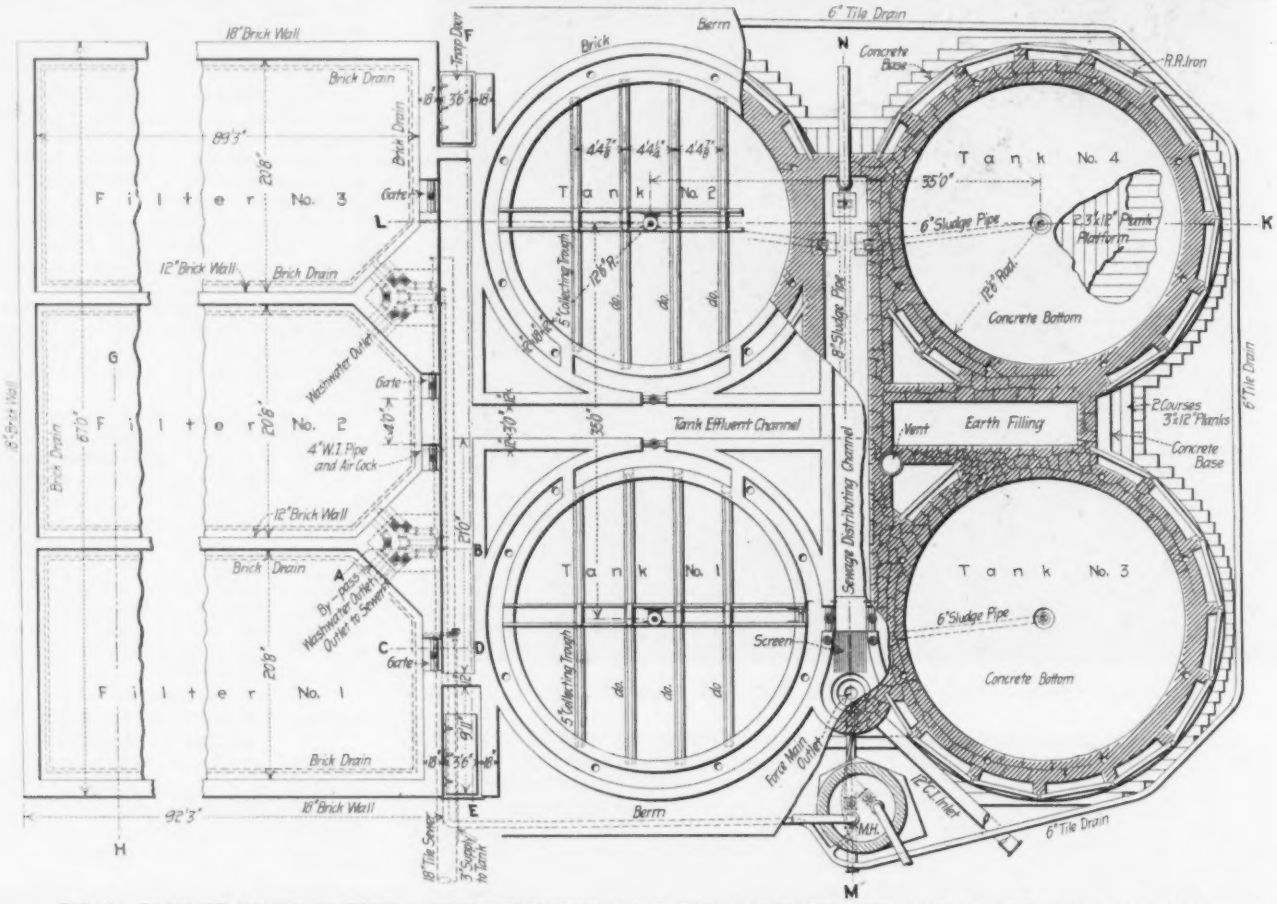

FIG. 1.—PLAN OF CANDY CHEMICAL PRECIPITATION TANKS AND POLARITE AND SAND FILTER BEDS, MADISON, WIS.
American Sanitary Engineering Co., Contractors; Wm. G. Clark, Chief Engineer.

The contractors are working (at least in part) under the proprietary process of the International Purification Syndicate, 109 Victoria St., S. W., London, Eng. The main features of the International process are the use of ferozone as a chemical precipitant, and polarite as a filtering medium for the tank effluent. The Syndicate also uses, at least in some of its later plants, the Candy precipitation tank. At Madison the Candy tank and the polarite as a portion of the filtering material are employed, but it seems that lime is used as a precipitant, instead of ferozone. According to Moore's "Sanitary Engineering":

> Ferozone, or magnetic ferrous carbon, is prepared from the same mineral that forms the base of polarite, but it is treated in a different manner.
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> • • • • • • •
>
> Polarite is the trade name for magnetic, spongy carbon; it is prepared from a peculiar description of iron found in certain parts of South Wales. In its original state it is hard, non-absorptive, and non-magnetic. It is carbonized in retorts, and treated by a patented process, and then granulated to the degree of fineness required.

An analysis of the material made by Sir Henry Roscoe (Crimp's "Sewage Disposal Works") showed the following constituents:

Magnetic oxide of iron	53.85%
Silica	25.50%
Lime	2.01%
Alumina	5.68%
Magnesia	7.55%
Carbonaceous matter and moisture.	5.41%

It is claimed for the polarite that it is a powerful deodorant, and that it oxidizes organic matter by means of the oxygen contained in its pores, and renewed from time to time from the sewage, or from air drawn into the filter bed. According

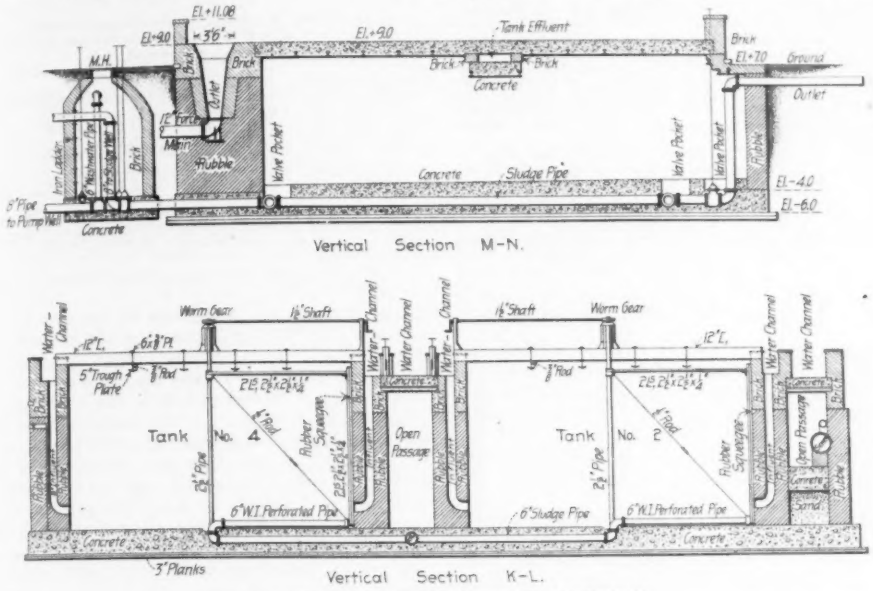


FIG. 2.—DETAILS OF PRECIPITATION TANKS.

to Dr. Arthur Angell (Crimp's "Sewage Disposal Works"):

> The action of the filter-bed is entirely independent of any property inherent to the polarite itself, which remains the same in weight and in bulk after an indefinite amount of oxidizing work has been done. Polarite is simply a carrier of oxygen and a means of bringing about a contact between that element and the foul matters in the filtering fluid. It derives its oxygen from the air and also from the tank fluid, and as these sources are inexhaustible, so also is the life and power of the filter bed.

The disposal plant at Madison is built out in a marsh. The outfall sewer of 22 and 24-in. vitrified pipe, partly with deep joints, is carried across the swamp from the city sewers to the plant. The sewer ends in a well, about 20 ft. deep, underneath the floor of the power-house. The sewage passes through a screen, which takes out the larger foreign substances. There are two screens, sliding vertically on the flanges of two channels as guides, one screen being in place while the other is raised for cleaning or repair. From the screen it passes to two vertical centrifugal pumps, having a combined capacity of 2,000,000 gallons in 24 hours. In these it is dosed with the lime solution, the strength and proportions of which are varied to suit the changing conditions of the quantity and quality of the sewage, from time to time. From the pump, the dosed sewage is forced through a vertical delivery pipe into a cylindrical chamber or well at the end of the channel from which the settling tanks are fed. The sewage passes through another screen, which takes out leaves, etc., which have passed through the first screen. It flows from the channel to the tanks through a weir in the side of the channel coping.

There are four circular settling tanks, 25 ft. diameter and 15 ft. full depth, built of brick, with a smooth facing of cement, and a concrete coping. Outside each tank is an annular chamber 18 ins. wide and 18 ins. deep, divided into two separate compartments by cross walls. One of these compartments of each tank is connected by a sluiceway with the channels from the delivery well. The dosed sewage flows into the four compartments, and down through 8-in. pipes at intervals. These pipes have horizontal ends entering near the bottom of the tanks. The sewage rises in the tanks, and is of a green color, the lime and solid matter forming the sludge being deposited in the bottom. Across the top of each tank are four iron troughs into which the sewage flows when it reaches a certain level, and by which it is discharged into the other compartment of the annular chamber above referred to. From there it is led to the three filter beds. The available depth of the tanks, or the distance from their bottom to the top of the collecting troughs, is about 14 ft., which would give a capacity of some 51,500 gallons for each of the four tanks, with no accumulation of sludge, or 206,000 in all. The tanks, it should be remembered in considering their working capacity, are not only operated on the continuous plan, but need be out of use only a few minutes' time when sludge is being removed from them.

Normally there are three filters in continuous use and the other one is out of use while it is being washed and then allowed to rest. Each should run from two to three days, and then be out of operation for about one day. The water used to wash the filters is led back to the sewage well, and is thus treated over again.

The filters are rectangular, 20⅞ ft. wide and 89¼ ft. long, built of brick on stone and concrete foundations. The bottom of each is paved with two courses of 4-in. semicircular tiles of porous red clay, laid at right angles to one another. Over these are a 4-in. layer of coarse broken stone, a 4-in. layer of fine broken stone, a 6-in. layer of sand, a 12-in layer of mixed polarite and sand, and a top layer of 9 ins. of sand. The total area of the three beds is about 5,550 sq. ft. The rate of flow through the bed is about 8,000,000 gallons per acre per 24 hours. The effluent is led to a discharge pipe of vitrified clay, and flows into an open ditch ending in the Yahara River, a small stream, the water of which flows into Lake Monona. Small fish in the river swim about in the effluent as it comes from the ditch.

The thin sludge in each tank is forced out at intervals through pipes leading to the sludge well in the power-house by means of a revolving pipe with perforations in its under side. This is operated from a shaft over the tank, turned by a crank handle. Rubber "squeegees" at the same time clean the smooth face of the tank. From the well the sludge is pumped by a triplex pump to the sludge press. The water from the press is led back to the sewage well for re-treatment. The sludge cakes are thrown into a steel dump car running on a narrow gage track, and are used in combination with sand for filling in the surrounding marsh. The output is about five to six tons of sludge per day.

The filter plant is apparently well built, and at the time of the visit of a member of the staff of this journal, last September, it was entirely free from nuisance. The only noticeable sewage smell was at the sewage well in the power-house, but this was not offensive, and ordinarily the well is closed. In fact, the smell from the gasoline engines was more marked and more objectionable.

For the machinery equipment, the sewage disposal company disclaims all responsibility. The machinery, laboratory, etc., are contained in a frame building on stone foundations.

The lime is slaked by hand, but as regards this and some other features of the plant it should be remembered that the original intention was to use ferozone, instead of lime as a precipitant. When

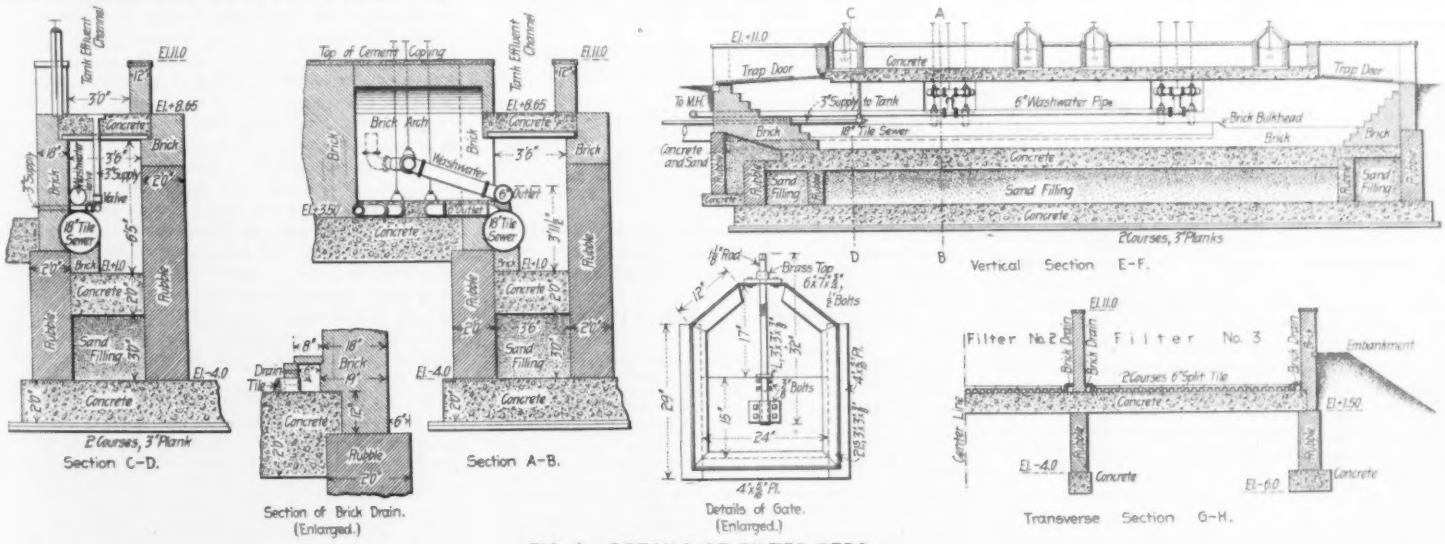


FIG. 3.—DETAILS OF FILTER BEDS.

the plant was built a chemical mixing tank, 6 ft. in diameter and depth, was put in. This was all the company thought necessary for the ferozone, which was said to require very little agitation. Over the tank described a dissolving tank, 3½ × 4⅔ ft., was erected, and later it, also, was provided with paddles, at the request of the company, but it never worked satisfactorily.

Three horizontal gasoline engines of 12 HP., supplied by Fairbanks, Morse & Co., of Chicago, drive the centrifugal sewage and the triplex sludge pump. The engines are connected to one shaft and one or more may be used, as desired. A gage shows the amount of sewage entering and the lime dose is varied to meet this.

The plant has been working steadily and continuously since early in June. How it will operate in winter can only be conjectured, the tanks and filters being exposed, and the temperature at Madison often falling far below zero. The company claims that the original plans called for a house over the tanks and filters, but the city concluded to omit this on account of the cost. The city, however, claims that neither the original plans, nor those adopted when the contract was made, showed any covering, and that it was not until

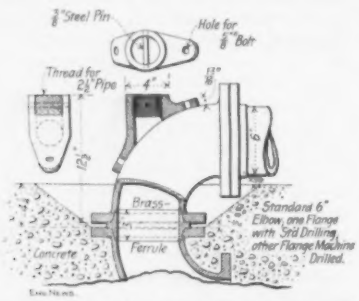


Fig. 4.—Pivot Joint in Sludge Collecting Pipe.

lately that the company admitted that a covering would be needed. It has not yet been decided who will pay for the covering, if provided, the company or the city.

The information thus far given, except the three opening paragraphs, was mainly secured on inspection of the works and from Mr. John MacDougal, General Manager, and Mr. Wm. G. Clark, of Toledo, O., Chief Engineer of the company, who also furnished the blue prints from which the illustrations were prepared. It has, however, been thoroughly revised and materially extended by Mr. Dodge, the city engineer of Madison, whom our representative was unable to see on his visit to the plant.

About Oct. 1 the company, having operated the plant for three months, tendered it to the city to operate for nine months before final acceptance, all as provided in the contract.

This precipitated a controversy over the efficiency of the plant which up to this writing has not been settled, so the plant has remained in the hands of the contractors for a second three months since its completion. In so far as this struggle is over purely local matters, it does not concern us or our readers, but there are a number of points involved which are of general interest. These will be better understood after citing some of the features of the contract, as laid down in a city ordinance authorizing its execution, the ordinance having been passed by the city council and approved by the mayor on April 11, 1898.

The first clause of the contract, after the preamble, is as follows:

That the sole purpose of putting in the sewage purification plant is for the purification of the sewage of said city so that the effluent may be turned into Lake Monona without contaminating the water of said lake, or causing or aiding vegetable growth in said lake, and without injury to the fish therein.

After reciting the location of the plant and its principal features and dimensions (as already described in this article) and providing that the construction shall be carried out to the satisfaction of the engineers employed by the city, the following conditions are laid down:

Said engineering company agrees to operate the works for three months after the date of their completion at the expense of said company. If said plant is working to the satisfaction of the said city engineers at the expiration of said three months, the city shall, at its expense, without accepting the same, assume the running control of said plant and shall continue to operate the same as directed by said company for a period of nine months before accepting the same. Said company specifically agrees and warrants to produce a degree of purification in the effluent from the filters, even when the plant is working at its full daily capacity, as follows, to wit:

(1) The effluent shall be at least as pure in all respects as the effluent from the sewage of the city of Madison would be if treated with lime, alum, or copperas, or lime and alum, or lime and copperas, or any combination of these, at the discretion of the city surveyor, and afterwards filtered through 5 ft. of specially prepared beds of sand, as heretofore proposed by said engineers, at the rate by them proposed.

(2) That when the said purification plant is properly operated the effluent, as it passes from the polarite filter-beds, shall be satisfactory to both of said sewerage engineers; that is, McClellan Dodge and Capt. John Nader, or the survivor of them, and that on chemical analysis it shall be as pure as the water of Fourth Lake, as shown by an analysis of said water made by Prof. Daniells, of the State University, at the request of the city, in the year 1888, and published in the water commissioner's report of that year.

(3) That the effluent passing from said plant may be turned into Lake Monona without in any way contaminating the waters of said lake, without causing or contributing to vegetable growth in said lake other than as pure water may contribute to such growth, and without in any manner doing injury to the fish therein.

(4) That the operation of said plant shall cause or produce no objectionable or offensive odors or nuisance in or about said plant, the Yahara River, Lake Monona, or in or about any other place.

(5) That said purification plant shall work in all other respects in a manner satisfactory to the said engineers of said city.

The company also agreed to give a bond for $25,000 for the satisfactory fulfilment of the contract, which sum equaled that to be paid by the city on the completion of the works. The city agreed to pay interest at 6% on the $12,200 retained by it until after the year of trial had passed, provided the city finally accepted the works and paid this balance.

Besides guaranteeing the purity of the effluent, the company agreed that the plant should have a daily capacity of 1,200,000 gallons, for each and every day of the year, that it should be tested at that rate before acceptance, or at a pro rata rate by using only a part of the plant, and that it might be tested to determine what results would be obtained when using lime, alum or copperas, with sand filters.

As to cost of operation the company agreed that this, including "labor, chemicals and other necessary supplies, as the city now proposes to operate its plant," should not exceed the estimated cost of operating the plant designed just previously by the city engineers (see above), namely, $3,600 a year for 600,000 gallons of sewage per day, including ferozone,

and that the cost of treating any increase in the sewage beyond that amount shall not exceed the proportion which the amount of ferozone then used shall be to the ferozone used in treating 600,000 gallons at the above figure up to the capacity of the plant.

The company agreed to furnish the city ferozone at cost for one year and thereafter to supply it at a cost not to

exceed the cost of alum or lime, or copperas, or any combination of these the city might see fit to use, for treating a like amount of sewage with as favorable results, and that the cost of sufficient ferozone to properly treat the sewage of Madison shall at no time exceed the sum of $1,500 per annum, for treating 600,000 gallons of sewage per day.

A clause in the contract-ordinance provided that the city should be under no obligation "to use ferozone as the coagulant" or "polarite in its filter beds."

As a final test of the plant the contract provided:

It is understood and agreed that at the expiration of the year of trial herein provided for and before the said works shall be finally accepted by the said city, the effluent as it leaves the filter-beds shall be satisfactory to Dr. Phil. Fox, Health Physician of said city; Hon. Robert G. Siebecker, Judge of the Dane County Circuit Court, and McClellan Dodge, City Engineer of said city; that the analysis of the effluent herein provided for shall be made by either Dr. Babcock or Prof. Daniells, of the State University, as the gentlemen above named shall select, and the effluent on such analysis shall be found to be equal to the waters of Lake Mendota, as hereinbefore provided; that the said Dr. Phil. Fox, Robert G. Siebecker and McClellan Dodge shall be satisfied that there shall be no nuisance in or about said plant, the Yahara River or Lake Monona, caused by the operation of said plant.

In conclusion, the contract recites at some length that the price for which it agreed to build the plant was made as low as it was because there was no plant of the kind in this country, although there were some in successful operation elsewhere, and the company was anxious to install a model plant in the United States as soon as possible.

Reverting now to the tender of the plant to the city: After this occurred, the city tested the plant for a week, taking hourly samples of the effluent. It was found that the albuminoid ammonia of the effluent ranged from 0.40 to 1.33 parts per 1,000,000. The four analyses of Lake Mendota water given in the report of the Water Commissioner of Madison for 1888 have been put in tabular form and are reprinted herewith. It will be noted that the contract employs the word "an analysis," in laying down this standard, without stipulating whether an average of the four analyses, the worst of them or the best, are to be taken. The figures are parts per 1,000,000.

Analyses of Lake Mendota Water (January, 1898) Adopted as Standard of Purity for Madison Sewage Effluent.

No. of sample.*	Chlorine.	Oxygen consumed in 15 mins.	30 mins.	45 mins.	Ammonia Free.	Albuminoid
1	1.6	5.04	6.3	12.0	0.392	0.288
2	1.5	2.0	3.1	4.6	0.202	0.254
3	1.6	2.42	2.85	3.1	0.201	0.284
4	1.6	1.5	1.9	3.1	0.226	0.317
Average	1.6	2.74	3.54	5.7†	0.255	0.280

*No. 1, 51-ft. sounding, 8 ft. from bottom; No. 2, 40-ft. hole, 7 ft. from bottom, 200 ft. from bar, sounding on bar 21 ft.; No. 3, 64-ft. sounding, 8 ft. from bottom; No. 4, 40-ft. sounding, 8 ft. from bottom.

†Omitting the abnormal figure of No. 1, the average for the three remaining samples is 3.6.

During the week of the test the volume of sewage was very uniform, averaging 350,000 gallons a day. Except during rainy weather the city officials do not believe that the sewage flow had ever exceeded 500,000 gallons a day up to Nov. 1, but for the early part of December they placed the daily amount of sewage at 520,000 gallons. On the other hand, the company claims an average flow of 600,000 gallons a day and that it sometimes goes up to 1,800,000 or 2,000,000 gallons. The company claims that this alleged extra flow is due largely to leaks in the outfall sewer, but the city urges that these were made good after the sewer was laid.

Shortly after the test just mentioned the city engineers recommended that the city begin to operate the plant for the nine months of final trial, and stated that the plant was satisfactory to them, except that results fell below the sanitary standard and exceeded the cost of operation named in the contract. Their report stated that these defects need not prejudice the city, in case it began to operate the works, because of the further provisions as to the nine months' trial and the approval of the plant by the three judges before its acceptance by the city. The council showed itself unwilling to assume the charges of the plant, until the engineers were satisfied with its operations, as provided in the contract, and arranged for an investigation by A. S. Mitchell, State Chemist, Prof. H. L. Russell, Dr. William Kempster, of Milwaukee, and Dr. Philip Fox, Health Officer of Madison. The gist of the reports made by these men, in the latter part of November and early in December, was that while the plant was effecting a fair degree of purification, the effluent was polluting the lake to a slight extent, and, moreover, that the plant is not large enough to do the work called for by the contract. Analyses of two sets of samples, collected on two different days, showed a removal of 68.35% of the total organic matter based on an average of the albuminoid ammonia and oxygen consumed. Some 91% of suspended matter and 34% of matter in solution was removed by the combination of chemical precipitation and filtration. The engineers for the city were of the opinion that the plant was not working so well in late November and in December as formerly. The city council, therefore, about the middle of December, instructed the mayor, city clerk, city attorney, engineers and the chairman of the sewerage committee to confer with the American Sanitary Engineering Co. and demand that the defects in the plant be made good.

One of the most serious objections raised against the plant, aside from the alleged inferior quality of effluent and excessive cost of operation, is that a part of the sludge has to be run out onto the marsh, without pressing. The company attributes this to improper sludge press and pump provided by the city and to other defects on the part of the city; but these claims are met by the statement that the company's change from ferozone to lime has increased the sludge beyond all expectation, and that the sludge is very thin, some of it being little more than dirty water. The

amount of lime used is placed by the company at 16 to 20 grains per gallon treated, with an average of 16 grains or over a ton of lime per million gallons of sewage.

Another alleged defect in the plant is that at times the filter beds not only have no rest, but actually work under a head.

When our representative visited the plant he found no objectionable odors there or in the vicinity, but such odors have been reported by at least one reliable person and by others regarding whose honesty or good judgment we know nothing.

DISCHARGE MEASUREMENT OF THE NIAGARA RIVER, AT BUFFALO, N. Y.

On Dec. 20, 1899, Mr. Clinton B. Stewart, C. E., presented to the Western Society of Engineers a paper with the above title, which is a most detailed and thorough description of the methods pursued in measuring the discharge of the Niagara River for the U. S. Board of Engineers on Deep Waterways, and the results of this work. It is impossible in the space available here to do little more than outline the work performed, and to give some of the general conclusions; but the full paper is a valuable engineering document, and it should be secured by those interested in similar studies.

The measurement was made between September, 1897, and September, 1898, and the discharge section was located on the north side of the International bridge, about three miles below the mouth of the river; at this point the total width of the Niagara River is 1,806 ft., with 129.5 ft. taken up by the width of the eight bridge piers. The distance between stations was about 20 ft., and the soundings were made with a 41-lb. cast-iron weight attached to a sash-chain for the swift and deeper water, and with a 25-lb. lead in the shallower water. The bed of the river was clay on the American side and rock on the Canadian shore; but no attempt was made to investigate the character of the material in the middle, though it is probably clay.

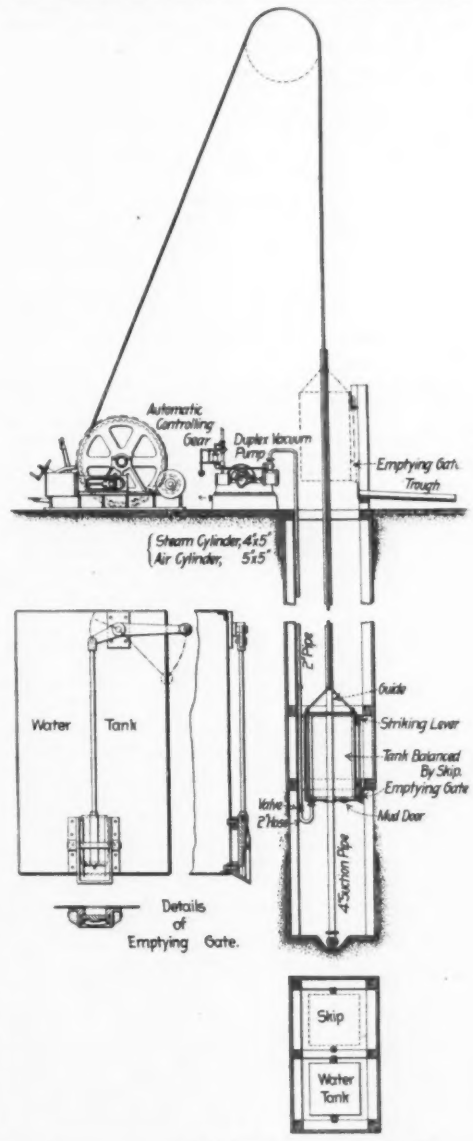
The water gages were of the box type with float, and eight of these gages were established, in September, 1897, at points on the American shore between the lake and the discharge section for determining the slope of the river in various reaches; five more of these gages were set in July, 1898, some on the Canadian shore.

The outfit for current observations included the following instruments: (1) A curent meter E No. 1, high and low pitch wheels, with a length of 16 ins., diameter of wheel, 4 ins.; weight of meter, 2¾ lbs.; weight of lead sinker, 20 lbs. (2) A direction current meter, form A No. 1; with low pitch wheels; length 36 ins.; diameter of wheel, 7½ ins.; weight of meter, 30 lbs.; weight of lead, 65 lbs. This meter is extremely sensitive and will measure velocities from 0.25 ft. to 10 ft. per second. (3) Current meter form B. All of these meters were of the Haskell type, and they were elaborately rated at Buffalo by methods fully described.

The general method of proceeding with the meter observations for discharge measurements was as follows: The meter stations were about 80 ft. apart, and all the observations for discharge were made at the 3-10 depth point. Observations at the surface were taken with the meter wheel 1 ft. below the water surface; and those at the bottom with the lead weight slightly clear of the bottom, so that the meter wheel was 1½ ft. above the bottom. The intervening depth was divided into ten equal parts, and the 3-10 depth point, with D representing depth of water, would be located at a distance below the surface of (3-10 D (D — 2½) + 1.) This expression was fixed for each station at depths corresponding to an approximate mean river stage, and the correction on account of stage was + 3-10 change in stage in feet. Corrections had also to be made in the swifter current, or about 6 ft. per second, for the angle made by the meter being carried down stream. Vertical and transverse curves were also observed, as well as the direction of current and the mean direction of flow of the river.

These observations were then reduced, and tables given show the exact cross-section of the river at this point—the total area of this cross-section being 39,629 sq. ft. at a water surface elevation of 567.0 above mean tide at New York. The table of mean velocity coefficients for computing discharge measurements shows that in changing from low to high stage of river this coefficient does not vary more than 2% and generally decreases. The table of detailed discharge measurements for each span shows an aggregate of 178,121 cu. ft. per second.

The table of discharges show that with strong winds the slope conditions are very changeable and the gages fluctuating. With the wind from the S. W. or N. E. the water at Buffalo is raised or lowered respectively from the mean level of the lake, and there is danger of the discharge being influenced by the conflict of the return lake current and the current in the river. But out of the 72 discharges figured, 42 have been accepted, and these cover a range of about 2.3 ft. in lake level. Taking the elevation of mean lake level of Lake Erie at 572.78, the mean of the lake level



Vacuum Tank System for Bailing Shafts.
Ross E. Browne, Inventor.
Fraser & Chalmers, Manufacturers.

observations at Cleveland for the period 1875-98, the corresponding discharge is found to be 220,190 cu. ft. per second. But by correcting for an apparent discrepancy of + 0.3 ft. in the usually accepted elevation, the discharge is figured at 221,500 cu. ft. per second. The rate of increase in discharge at each foot of elevation of lake surface between elevations 570 and 574 lies between 17,762 and 29,034 cu. ft. per second; the rate of increase in discharge, per foot of rise of lake, at mean lake level, is about 25,000 cu. ft. per second.

Should a certain amount of the discharge of the lake be diverted from the natural outlet, the effect on the lake level can be directly obtained, by taking the proportion of the amount diverted to the rate of increase or decrease in discharge per foot of rise of lake. Thus, should 10,000 cu. ft. per second be diverted from the Niagara River discharge by the Chicago drainage canal, the effect would be to lower the level of Lake Erie by $\frac{10}{25}$ — or 0.4 ft. The effect on the level of Lakes Michigan and Huron by diverting this quantity of water cannot be exactly known until the form of the discharge curve for the St. Clair River has been determined. But judging from the form of the outlets and the data obtained at Niagara, the effect of diverting 10,000 cu. ft. to the drainage canal would be to lower the mean level of these lakes by 0.5 ft.

VACUUM TANK FOR BAILING OUT SHAFTS.

In sinking shafts, considerable difficulty is sometimes experienced from the inflow of water from the sides, which hinders the work in the shaft, and is difficult to remove without further interference with the work. In ordinary practice, some form of suction and lift or force pump is used, operated by steam, compressed air or electricity, or by rods actuated by machinery on the surface. The pump is placed in the shaft, 15 to 25 ft. above the bottom, drawing the water by a suction hose or pipe, the end of which is fitted with a strainer and dropped into a sump. While the work of sinking is in progress, only a small sump can be provided and the pump, therefore, has to work under unfavorable conditions, drawing air, water, mud, etc., which causes more or less rapid wear of the machinery, and more or less continual repair and attention. The pump must also be lowered from time to time as the work progresses, and the water pipes and power supply pipes must also be extended. During blasting operations, also, the pump must be well protected by a bulkhead of heavy timbers, or it may even have to be removed. All this attention, handling, adjusting, repairing, etc., of the pump and its connections, with consequent delays, adds materially to the cost of sinking the shaft.

The accompanying cut illustrates a device which is intended to greatly reduce the expenses, difficulties and delays incident to the pumping out of the shaft. It consists essentially of a large vacuum tank which may be raised and lowered rapidly by a suitable winding engine on the surface. A vacuum pump is also installed at the surface, and may be driven by any convenient power. The tank is fitted with a strainer, foot valve, suction hose, suction valve and discharge gate. It is lowered from the shaft until the suction hose is in the sump. The air hose in then attached, and a vacuum being created, the water, mud, etc., rush in and fill the tank. The air hose coupling is then detached, and the tank is hauled rapidly to the surface, where the discharge gate is automatically opened by a striking block, and the water is delivered into a trough or flume. The tank is again lowered and the air hose connected up as before. Similar forms of coupling are already in use for other purposes. The tank may be worked in one compartment of the shaft, if it is divided by timbering, and should be fitted with shoes running on guides. The device may be adapted to inclined shafts. The plant shown in the accompanying cut has a capacity of 60 gallons raised 500 ft. per minute.

This system has been invented and patented by Mr. Ross E. Browne, M. Am. Inst. Min. E., 44 Nevada Block, San Francisco, Cal., who informs us that it has not yet been put into practical use. It it being manufactured and introduced by Fraser & Chalmers, of Chicago, to which firm we are indebted for plans and other information.

THE ANATOLIAN RAILWAY CO. OF ASIA MINOR has received a preliminary concession for a railway line from Koniah to Bassorah. The concession was obtained by Dr. Von Siemens, of the Deutsche Bank of Constantinople. A press dispatch states that an agreement has been concluded between the railway company and the Porte for an advance of £1,200,000.

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In ordering changes of mailing addresses, state BOTH old and new addresses; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 329 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1899; the change of these figures is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXII. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

The "Southern Trade Record," published at Cincinnati, O., appears to be a twin brother of the "Southern Review of Commerce," whose celestial methods of journalism were set forth in our issue of Dec. 14. A copy of the "Record" of Dec. 4, which lies before us, is practically a duplicate in make-up and general style of the other journal named. Each article in the paper begins with the statement that numerous subscribers have sought the editor's advice as to the best firm in some particular branch of trade. In response to these inquiries he has set in motion his "large force of representatives in various parts of the country" with the result that one particular firm is invariably selected as superior to all others, and its products are lauded to the skies.

In the number before us this versatile editor and his remarkable corps of assistants have investigated and reported upon wood fireproofing, writing paper, wood preservative, sidewalk bricks, cattle dehorners, saddlers' goods, coach varnish, crash towels, watchmakers' lathes, nursery stock, carriage bodies, linen papers, bookbinders' machinery, furnace brick, plate glass, whiskey, forks, shoe lasts, civil engineers, sanitariums, gas scrubbers, needles, refrigerators, curled hair, plows, steel castings, shoe blacking, mica chimneys, woolen goods, wire work, bleaching powders, anvils, dress goods, spokes, life insurance, stock brokers, maple syrup, burglar alarms, churns, cheese bandages, champagne and bedsteads. There are a few others, but the list is long enough, and champagne and bedsteads make a good closure. Perhaps it was his labors in investigating the former article and the whiskies that caused the editor in this number to commit the grave error of selecting and setting forth two different firms in the same line, as each the best. On the first page we are assured that the best writing papers on the market are those made by the Parsons Paper Co. A few pages further we learn that the writing paper made by a firm in Mittineague is the best. Here are the two stories in parallel columns:

The "Southern Trade Record's" free offer of investigation on any subject pertaining to the trades has been the means of building up our circulation many thousands more than any similar publication in the country, and in view of the policy of the paper have come numerous inquiries from stationers throughout the South, requesting us to give them the name and address of a manufacturer of fine Bond in colors, as well as other first-class papers. We, as usual, carefully investigated the matter, and through local inquiries, and also through our representatives scattered throughout the country, we found that the best on the market are the high-grade papers made by The Parsons Paper Company, Holyoke, Mass.	The "Southern Trade Record" are asked to recommend the best line of linen paper on the market, and state where it can be purchased. We have made extensive inquiries locally, and also referred the matter to our representatives in all the principal cities. "The "Bankers' Linen," made by The Southworth Company, at Mittineague, Mass., is conceded to be the best which can be found on the market. These papers have been kept in the lead for years. Be sure that you get these and you will have "the best." The "Southern Trade Record" has the largest circulation of any trade journal in the United States, and no other publication of its class could employ such a large staff of experienced editors to make these expensive investigations.

Here is the way that the editor eulogises a certain civil engineer, to whose praise he devotes over a column of space:

There is nothing which this journal abhors more than the fulsome praise or adulation, yet it would not fulfill the trust reposed in its columns by its subscribers if it did not recognize great skill and ability wherever it finds them. Hence it has no hesitation in saying that as a bridge and railway engineer, Mr. ———— stands without a peer from a scientific and mechanical standpoint, perhaps, in the world; certainly in the United States. . . .

In conclusion, we might add that this was written in answer to a large number of inquiries from our subscribers as to who was the best bridge contractor in the United States, and after a careful investigation we found that the work done by Mr. ———— was equaled by none.

For one more example of the remarkable discrimination exercised by the editor of this journal, we resort again to the "deadly parallel column:"

Recently the industrial editor has received an unusually large number of queries on the subject of sanitariums, or institutions for the treatment and cure of mental and nervous diseases. In making our examinations and investigations, there are none where greater care and caution are taken and manifested than about those which pertain to the sanitary conditions of the people, or about those who are engaged in the curing of disease. To respond intelligently to those queries, we have corresponded with a great many of the leading physicians in the country. We interviewed personally as many as were available, and almost with universal accord there was an expression in favor of Dr. Givens' Sanitarium, Stamford Hall, Stamford, Conn. In conclusion, we might further add that our indorsement of this institution is solely and purely for the benefit of our own patrons and those who have sought from us information, and that we are in no way interested in Dr. Givens or his sanitarium directly or indirectly; he is not even a subscriber nor an advertiser to our paper. We commented favorably on his worthy institution because it merited favorable mention, and with the hope of favor or reward from no one save our own subscribers, to whom alone we are responsible.	Recently our industrial editor has received an unusually large number of queries on the subject of mental and nervous diseases, with special reference to the foremost institution in the country for their treatment and cure. In making our examinations and investigations there are none where greater care and caution are taken and manifested than about those which pertain to the sanitary conditions of the people, and the treatment and cure of disease. To respond intelligently to those queries we have corresponded with a great many of the leading physicians of the country. We interviewed as many personally as were available and almost with a universal accord there was a general expression in favor of "Interlaines," a quiet, beautiful and restful home for the nervous invalid, conducted by Frederick W. Seward, M. D., at Goshen, N. Y. In conclusion, we might add that our indorsement of this institution is solely and purely for the benefit of our patrons and those who have sought information from us, and that we are in no way interested with this institution, or Dr. Seward; he is not even a subscriber, nor an advertiser, of this paper. We commented favorably on his institution because it merited favorable mention, and with the hope of favor or reward from no one save our own subscribers, to whom alone we are responsible.

We trust the "industrial editor" will hasten to choose one or the other of the above named institutions, and commit himself to its care. His brain seems to be worn in grooves.

The railway safety appliance law has again had the date at which it will take effect postponed by the Interstate Commerce Commission. A hearing was held at Washington on Dec. 6, in which the railways petitioned for a further extension of the time allotted to complete the equipment of freight cars with automatic couplers and air brakes, as required by law. It was urged that the pressure of traffic had been so great during the past year as to make it difficult to spare cars from service to apply the equipment. Besides this, the scarcity and high price of iron had made it difficult to secure the necessary material. The commission on Dec. 19, announced that the date for the operation of the law would be extended to Aug. 1, 1900. After that date it will be illegal to move in interstate commerce any car not equipped with automatic couplers or any train not equipped with air brakes. A statement of the cars equipped and not equipped on Dec. 1, 1899, as reported to the Commission, shows that a large number of roads are still far behind in the matter of equipment. The Vanderbilt lines, however, are notable among the large system for having entirely completed their equipment, and nearly all the large systems have the situation well in hand, and should be able without difficulty to complete their equipment during the next seven months. It is rather doubtful whether the commission will grant any further general extension of time; and any road which pleads for a particular exception to be made in its favor will need to show very sound excuses indeed for its past derelictions in order to secure it.

PROPOSALS FOR IMPROVED TRANSIT FACILITIES ACROSS THE EAST RIVER AT NEW YORK.

The movement to secure the construction of two new bridges across the East River at New York city, which has progressed so swimmingly since it was launched by the city administration twelve months ago, has apparently struck a snag in the unexpected and vigorous counter-movement to construct tunnels in place of bridges, which we describe elsewhere in this issue. As we have pointed out there, both of these movements have their origins within the city administration and each is being earnestly pushed by its advocates, apparently with entire belief in its superiority as a means of East River transit. As matters now stand, our readers will observe that there are two resolutions in behalf of the rival plans before the Municipal Assembly for consideration. The first of these resolutions emanates from the Board of Estimate and Apportionment, and requests the appropriation of $2,000,000 (or rather the issuance of city bonds for that amount) with which to begin immediately the construction of two new bridges. The second resolution was handed in by the Board of Public Improvements, and asks for an appropriation of $75,000 to be expended for making preliminary surveys and plans for two East River tunnels. The final action of the Municipal Assembly on these resolutions cannot, of course, be foretold with any degree of certainty, but the indications now are that a compromise will result. In any contingency, however, the issue between bridges and tunnels as means for crossing the East River has been definitely presented for the consideration of the public, and is receiving unstinted discussion in the daily press.

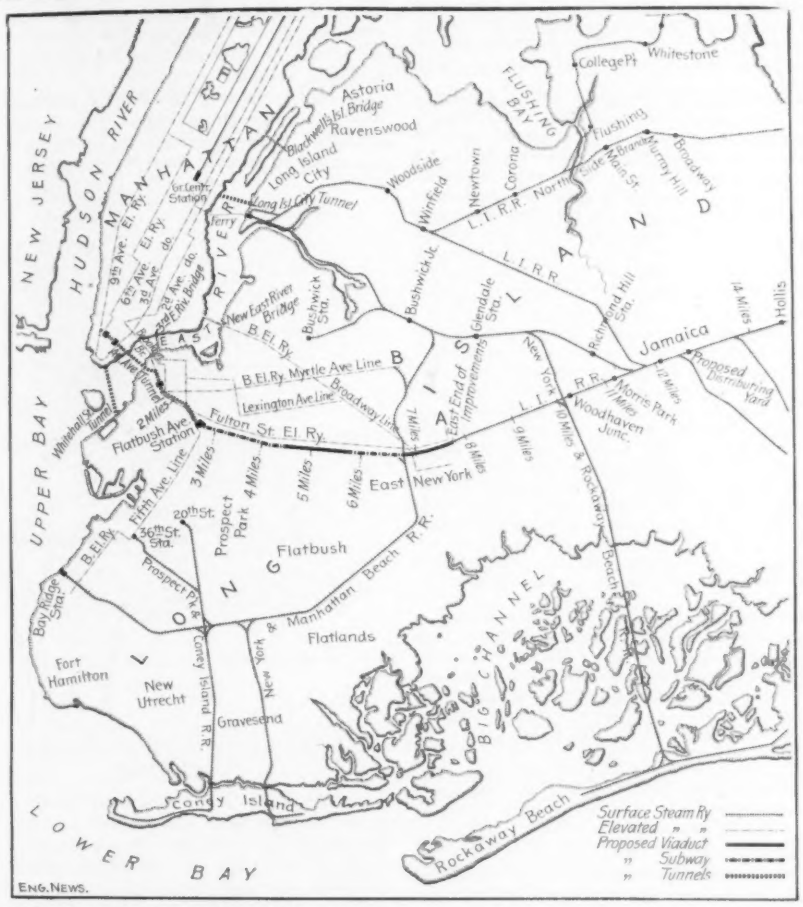
Let us see briefly just what are the questions at issue in this controversy. To proceed with the building of either bridges or tunnels, is to assume, in the first place, that there is a great demand for additional means of transit across the East River beyond those already provided for. The correctness of this assumption is far from being clear, but admitting it for the sake of argument, the question then comes up: what means are best for supplying this demand? Will tunnels best subserve the conditions to be met, or will bridges prove preferable, or is it possible that a combination of bridge and tunnel lines may best meet the requirements of the situation? It is fairly clear, to engineers at least, that to give any off-hand or merely general answer to questions like these is absurd. Before fair conclusions can be reached, transportation and traffic problems must be solved as well as the structural problems in connection with the making of either bridges or tunnels.

The assumption that the additional bridges or tunnels proposed by the city administration are needed is evidently reasonable only in case it can be shown either that there is a present unaccommodated traffic of sufficient dimensions to pay for the enormous investment required to secure them, or else that there will result at an early date indirect financial advantages of a similar profitable magnitude, such as the opening up of unoccupied residence property, the increase of real estate values, etc. (not offset by corresponding reductions in other localities). Unless one or both of these possibilities can be shown to exist, there can evi-

dently be little real justification for the city expending the large sum of money necessary to build the proposed bridges and tunnels.

It must be remembered that there are other and urgent demands for the expenditure of the city's revenues on income yielding improvements, such as increase in the water-supply, construction of additional docks, building the rapid transit railway. That money spent in these directions will yield a good return is well proved. Investment in more East River bridges or tunnels, on the other hand, can bring at best only an indirect return.

Again, the New York taxpayers are groaning under the burden of increased assessments. Further burdens of debt ought only to be loaded on Father Knickerbocker's shoulders, if the debt is of a kind



SKETCH MAP SHOWING ROUTES OF EXISTING AND PROJECTED BRIDGES AND TUNNELS ACROSS THE EAST RIVER AT NEW YORK.

which will pay for itself or if the necessity is so great as to make the expenditure practically compulsory.

The present city administration has, in fact, repeatedly recognized the need for economy in the conduct of the city's finances. It has repeatedly declared that the city was too poor to expend money in costly public works. The rapid transit railway has been held back because the city, it was said, had exhausted its credit. The new East River bridge has been delayed on the same plea, and the same excuse has been repeated by at least one of the parties in the present conflict between the bridge and tunnel interests as a sufficient reason why its plans should be preferred to the plans of the other party. This plea of poverty, if it is justified, holds as good in one case as in another where the txpenditure of the public funds is required. If one public improvement is to be planned and carried out while others are held back, it can be done consistently only on the condition that the former demonstrates at the outset its capacity to make direct or indirect returns for the money expended which the latter do not.

According to the city administration's own showing, therefore, the public is fully justified in asking what adequate return the construction of costly bridges or tunnels across the East River will furnish either directly or indirectly to the taxpayers. The administration has set forth in answer the claim that the opening up of unoccupied residence areas and the increase in real estate values, which will follow, will by themselves warrant the construction of the proposed lines. Proof of this contention, however, is thus far lacking. It can be true only upon the supposition that the traffic through tunnels or across bridges will from the very beginning, be sufficient to pay their operating expenses, and also the interest on their cost. If the receipts from traffic fall below these expenses the deficit will be a charge against the community, which may be very small if the deficit is small, or which may, if the deficit is large enough, be sufficient to overbalance, by increasing the already heavy tax rate, any local advance in real estate values which will result. The question of the possible returns from the bridge or tunnel lines which are proposed, therefore, practically resolves itself into the question of what traffic is available to support these lines.

The traffic across the East River is essentially a long distance city passenger traffic. It is made up nearly wholly of the travel of people living beyond walking distance from the various river crossings, and who must, therefore, travel by railway to and across them. This is the paying traffic which a bridge or tunnel line must depend upon for its support. The team traffic is almost wholly a river front traffic. It employs animal power, and for this reason will seek the shortest and easiest routes, and those making the least demand upon the strength of the draft animals. For obvious reasons ferries are far better suited to handle traffic of this class than either bridges or tunnels. As for the pedestrian traffic, it is trifling in amount, and is rigidly limited by distances to a small area tributary to each crossing. It is reasonably plain, therefore, even from this brief analyses, that if there is a warrant for the proposed bridge or tunnel lines at all, it must be presented by the unaccommodated rapid transit passenger traffic, and a large part of this is already being provided for by the new East River Bridge, which is under construction, while another part could be accommodated by the Long Island R. R. tunnel line, which the city administration is ignoring apparently for no better reason than that to permit the construction knocks a strong prop from under its argument for more bridges.

A glance at the accompanying sketch map will show from what a productive area of traffic this projected tunnel line of the Long Island R. R. will draw business. It virtually controls the traffic of the suburban Long Island villages with New York city and Brooklyn. Its construction accomplishes the abolition of grade crossings, which the city of Brooklyn has sought for years. Beyond a part share in the cost of grade crossing removals, amounting to $2,500,000, the construction of this tunnel will cost the city nothing. Evidently every consideration of economy and the honest desire for better East River transit should urge the city administration to facilitate the completion of this project. Instead of this it has held an ordinance which will allow work on this tunnel to begin, unacted upon in one of its committees for over six months, and it ignores all requests for its speedy passage. Meanwhile it pushes ahead a plan to build two bridges which cannot cost less than $35,000,000. One of these bridges is so located as to drain exactly the same territory as the present Brooklyn bridge. The other terminates in a sparsely settled section of an outlying borough whose traffic is all in the future.

No one who studies with an open mind the accompanying map can doubt that the wise course, if better East River transit facilities are really desired, would be to push the Long Island R. R tunnel to completion before all other schemes which have been proposed. With this line completed, and the New East River Bridge open for traffic, where would be the traffic for additional bridges or tunnels? Certainly it would not be found at a location barely a quarter of a mile from the present Brooklyn Bridge, nor does it seem likely that it could be found at a location which begins in the marshes of Queens County and ends nowhere in Manhattan.

Of all the routes for either bridges and tunnels which are now proposed, there is in fact only one which recommends itself as having some reasonable basis for its selection. This is the proposed tunnel route from the lower end of Manhattan Island to South Brooklyn. Here is a section of Brooklyn which neither the present Brooklyn Bridge nor the New East River Bridge nor the Long Island R. R. tunnel provides for, and in it is contained nearly half the population of the city.

To permit the completion of the Long Island R. R. tunnel will cost the city nothing. The cost of the proposed tunnel to South Brooklyn may be liberally estimated at some $5,000,000, assuming, of course, that favorable conditions are found. To build the two bridges which are projected will cost at least $35,000,000. As a business investment there can be no doubt which project is preferable, nor does it require much assurance to prophesy that the two tunnel lines will fulfil far better the present needs of traffic than would the two proposed bridges. To speak plainly: It would be a flagrant misuse of public funds to build a bridge where the proposed third East River Bridge is located, and leave neglected these two tunnel lines, which can be built at less than half its cost to the city. There is a little more reason for the bridge at Blackwell's Island. A structure here can be constructed at much less cost in the first place, and it will give access to Manhattan Island for a district which is now without satisfactory means of transit, and which is quite certain to grow in population as time goes on. At the present time, however, there is far from enough traffic to warrant the construction of a bridge at this point.

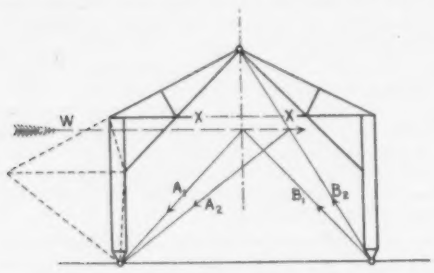
In conclusion it may be noted, for the benefit of the disputants over the relative advantages of tunnels and bridges, that the question must be settled in each case by the local conditions which prevail. Any general assertion that tunnels are better than bridges or that bridges are better than tunnels for crossing the East River is absurd. The construction of a bridge to South Brooklyn is impracticable, and on the other hand at Blackwell's Island, where nature has placed a bridge pier in the river, a bridge is the most logical solution of the crossing problem, whenever a crossing at that point shall become necessary.

LETTERS TO THE EDITOR.

Graphical Analyses for Wind Pressure in Mill-Building Frames.

Sir: Mr. Geo. H. Hutchinson, in his treatise on "Mill-Building Construction" (J. B. Johnson's "Modern Framed Structures"), considering the stresses due to the wind-pressure, figures the components of the reactions at foot of columns and then, introducing two new forces applied at foot of knee brace and top of column, starts with the force polygon at the foot of the knee braces. It seems to the writer to be perhaps a little simpler, because it avoids all figuring, to do the same thing in the following manner:

Intersect the lines: resulting wind-pressure and center line of truss. Connecting this point with the supposed hinges at the base of columns gives the reactions A_1 and B_1.



Draw the lines which are dotted in the sketch, and start the force polygon at the base of the column. It is obvious that the dotted lines have no influence on the forces in knee brace and truss members for which we care.

This method, for its simplicity and fair approximation of the forces produced by an assumed wind-pressure, is certainly preferable to any other.

It may be of interest to see how the above given graphical way to start the solution points directly to the more exact treatment of the problem. Project the line of the resultant wind-pressure a little further, until it intersects a line, which connects the peak of the truss with the base of the right-hand column, and take this as the point where the reactions A_2 and B_2 meet. This would mean looking at the frame as some sort of a three-hinged structure. If we assume the member marked X omitted, it actually would become one, with hinges at the bases of the columns and peak of the truss. Now this is the first step if the solution of the problem should be made more exact and according to the modern method to figure indeterminate structures according to the theory of least work. Very truly yours, Max. Werner.

11 Broadway, New York, N. Y., Dec. 11, 1899.

Engineering as a Profession and as a Career.

Sir: Ever since I first knew the railway, there seems to have been going on a contest between the engineering department and the operating department, with the result that the engineering department has been worsted.

On six of the eight roads whose systems of engineering and operating organization were described in the Engineering News of Oct. 19, 1899, and probably on six out of eight roads throughout the country, the only railroad engineering left to the undisputed possession of the engineering department consists of works of magnitude and bridge building. This condition, although, no doubt, conferring a dignity upon the engineering department, as being thus a department dealing only with great things, cuts off opportunity for the subordinates of the department to rise.

There is not, to-day, on any railroad more than a few engineering positions, generally not more than one, as well paid as are the division superintendents in the operating department; and as a natural consequence an assistant engineer on surveys, on construction, or on bridge work, will remain, year after year, "where he is at," neither gaining the advantage of promotion nor affording place for others to succeed him. Clearly, therefore, a young man seeking employment on a railroad should avoid service under the chief engineer, and aim to enter the operating department, where there are opportunities for advancement; and although an engineering education may help him at the start, he should look upon engineering as being simply a stepping stone to an executive position, perhaps that of roadmaster, or trainmaster, opening up possibilities of a superintendency or a general superintendency; leading ultimately, it may be, to a vice-presidency.

But our neophyte, if he has a higher ambition than to serve all his adult active life in a salaried position, might better, no doubt, turn his eyes away from the railway altogether. By volunteering for nothing a year in a good business house, as soon as he has obtained a common school education, it might be within the possibilities for him to be living in and owning a comfortable home, when forty years of age. Not probably so, by his own exertion, had he chosen to be a railroad man.

Nor will the experiences of a successful business man fit him in a less degree than an engineer is fitted to deal with questions where trained perception is required. Indeed, so commonly is it true and so generally is it admitted to be true that the possession of wealth implies also the possession of wisdom that whenever public works of magnitude are to be planned, the plan making is, almost invariably, entrusted to successful men of affairs, and not to engineers. It is, in fact, seldom or never that a legislative act creating a commission to plan a system of water-works or of transit for a great city makes any mention of the engineering profession at all. If engineers be allowed any part in such plan making, it is not more than to make surveys, and fill in details of the plans after their important characteristics have been determined by commissioners, who, without education or experience in engineering, are in public estimation wiser than engineers.

All parents of boys for whom careers are sought might profitably observe that the reason why some men are the employers and masters of engineers, and other men are the engineers who are employed and serve, is simply a consequence of the fact that certain boys went to work in business houses and other boys matriculated at scientific schools.

So indistinguishable, indeed, is the difference between the mental ability of a capable chief engineer of a great railroad and the mental ability of an able financier, as to make it easy of belief that if the training and experience of the capable engineer had been the same as the training and experience of the able financier, he who became the capable engineer would, instead, have become an able financier. And of men lacking the ability to rise towards the top either in business or in engineering, the earnings of such men, no doubt, would be quite as good in the mercantile world as in any subordinate place on a railroad.

Nor can it be said that engineers may pride themselves for any public distinction which men of business may not enjoy. Orators, poets, statesmen, philanthropists and men for any cause held in high public esteem are as many of them men who began with hard knocks as there are who were graduated from colleges; and among men thus distinguished is almost never any civil engineer. To go into the market place, back one's self to win, and succeed; to become a writer or speaker, to act as director of public affairs and employ engineers, these are among the possibilities for a boy who goes to work at the bottom of the ladder.

And these are the possibilities which are withheld from the boy who goes to an engineering school and adheres to engineering.

It is true that some engineers have, now and then, given up engineering and worked their way into a prosperous footing among men who are the employers and not the employed. But not every man can thus find opportunity to correct an error of youth by making, later in life, a new choice of career. Is it not, of truth, written, that "as the twig is bent, so shall the tree incline?" To all those many engineers, in middle life or older, who are struggling along, only a degree removed from poverty, engineering has become like the cage to Mr. Sterne's starling: "I can't get out," said the starling, "I can't get out." One Who Has Been an Engineer.

New York, Dec. 19, 1899.

(Our correspondent draws with fair accuracy one side of the picture; yet there is another side which he does not present, and which is to be remembered by the young engineer. The engineer who follows engineering as a profession merely can expect, we are sorry to say, only a moderate return even if he attains to a degree of professional skill which brings fame and fortune to a lawyer or physician. On the other hand, if he unites to his engineering knowledge and skill, abilities as a leader and director of men and of affairs, he has opportunities for achieving a position in the business world as good or better than those that come to men in any other vocation. There are plenty of engineers who have seized opportunities at the right time and won their way to responsible positions and wealth. There are plenty of others who for lack of opportunity, or lack of the nerve and foresight to grasp the opportunity when it came, have gone on year after year, only one remove from poverty, as our correspondent says. Perhaps they might have done no better had they undertaken a mercantile life. A thorough education is more and more becoming a necessity to the man who aspires to attain any large success in any walk of life, and there is much reason to believe that an engineering education is as well calculated as any to prepare a man to grasp success when she comes his way.

Finally, let us remind our correspondent, that the road to an independent position and a competence in either mercantile life or manufacturing industry is far from being as easy as it was twenty years ago. The department store and the revolution in methods of business are driving out the small retail merchant. The small manufacturer cannot compete with his huge rivals save under a heavy handicap. On the other hand, these changes are increasing the demand for men of thorough training and ability, who can be trusted with the largest responsibilities and who can always be relied on to do the right thing at the right time. Such men are in demand and herein lies the hope for the engineer of the future. Ed.)

THE ASSOUAN DAM.

As most of our readers are aware, work is now in progress on a great masonry dam across the River Nile at the Assouan cataracts, for the purpose of storing water for irrigation. A recently published treatise on "Egyptian Irrigation," by Mr. Willcocks, contains an account of this work, which is abstracted in our English contemporary, "The Engineer," and from the latter we have reproduced the accompaning illustrations and descriptive matter:

In connection with the further utilization of the Nile for irrigation purposes, the Egyptian Government, on the recommendation of the Technical Commission, decided upon the Assouan site for its

Map Showing Location of Assouan Dam and Island of Philae.

reservoir dam. But, influenced by the desire to save the Temple of Philæ, so precious to archæologists, they limited the level of stored water to R. L. 106 m. This decision has hurt the reservoir, and may not in the end save Philæ, unless it be lifted bodily, as suggested by Sir Benjamin Baker, or be removed to an adjacent higher site, as proposed by Mr. Willcocks. But the dam is being built, meanwhile, and the work generally is making rapid progress.

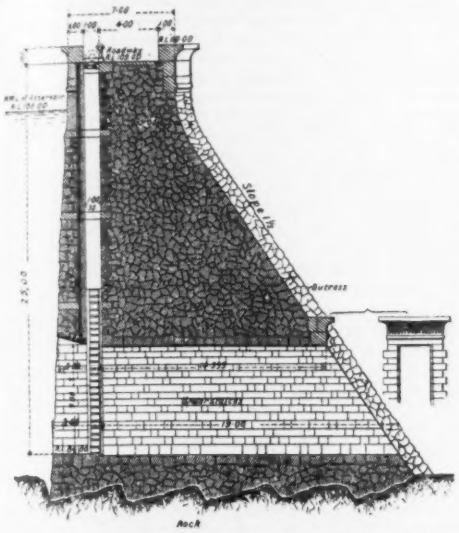
The maximum water level, on the upstream side, will be R. L. 106.6 m., and the minimum level below the dam will be 86 m.; giving a greatest head of 20 m. and providing a reservoir capacity of 1,065 million cu. m. of water. This reservoir will be filled between November and April, after the floods have subsided, and will furnish water for irrigating in May, June and July. The loss by evaporation is assumed to be 1 m. vertically, or 7% of the total contents, or 75,000,000 cu. m. per annum. This would leave 990,000,000 cu. m.; and deducting the losses from various causes in its 13½ days' travel, of 530 km., to the barrage at Assiout, there would be left a net quantity of 763,000,000 cu. m. to be utilized at Assiout. Mr. Willcocks contends that this volume is totally inadequate for the complete supply for perennial irrigation, and that sooner or later other reservoirs must be constructed, or the outlets of the great lakes at the sources of the Nile must be regulated. He points out how this could be done.

The Assouan dam is straight in plan, 1,950 m. long, and founded throughout on solid granite rock. The maximum height will be 28 m., with 20 m. as the maximum head against the dam. At its top the dam is 7m. wide, and 24.5 m. wide at the bottom. These dimensions meet the recommendations of the Commission that the maximum theoretical pressure on the downstream toe of the dam shall not exceed 5 kg. per sq. cm. The dam

is not to be submerged and is pierced by 140 under-sluices, 2 m. wide by 7 m. high, and by 40 upper-sluices, of half this area; all the upper and 20 of the under-sluices will be lined with cast iron.

During the flood season all of these sluices will be open and the whole flood of the Nile will be discharged through them; the extraordinary maximum discharge being 14,000 cu. m. per second, with a mean maximum of 10,000 cu. m. per second. The under-sluices will be regulated by Stoney's self-balancing gates.

Navigation around the dam will be provided for by a canal and four locks, with a total length of 1,000 m., on the left bank of the Nile. This canal will be partly in the solid rock, and partly between banks; the bottom width will be 15 m. Three of the locks will have a rise of 6 m. each and one will be 3 m.; and each lock will be 75 m. long in the clear and 9.5 m. wide. The height of



Cross-Section of Assouan Dam Through an Under-Sluice.

the lock gates will range from 19 m. to 6 m., as the canal must be used when the dam is full, as well as when it is empty. The gates will be single-leaf, rolling back into recesses at right angles to the axis of the lock. They were designed by Mr. F. G. M. Stoney, M. Inst. C. E. A lift bridge, hinged to and forming a part of a fixed bridge, carries two rails, and on these travels a carriage from which the lock-gate is suspended. The gate seats against steel quoins and a steel sill, and it contains valve openings for filling and emptying the lock.

In order to properly utilize the water stored by the Assouan dam, it became necessary to construct the Assiout barrage across the Nile, 530 km. below the dam, and below the mouth of the Ibrahimia Canal, and to place a regulator at the mouth of the canal. This barrage will consist of 120 openings, of 5 m. each, with piers, 2 m. wide, between. There is also a lock, 80 m. long and 16 m. wide, sufficient to pass the largest steamers on the Nile.

The estimated cost of the work is as follows:

Assouan Reservoir—		
Dam	£834,000	
Lock	143,000	
Contingencies	40,700	449,000
Land, etc.	248,000	£1,225,000
Assiout Barrage—		
Regulator	333,700	
Lock	74,600	
Ibrahimia Canal-head—		
Regulator	32,900	
Lock	36,100	
Contingencies	7,000	76,000
Total		£1,750,000

TEST OF THE POWER PLANT OF THE CAPITAL TRACTION CO., WASHINGTON, D. C.

The following data are abstracted from theses presented by Messrs. William R. Miller, Nelson E. Otterson, Frank H. Eastman and H. Worthington Talbott, graduates of Cornell University. The theses were prepared from the results of tests made by them upon the electrical power plant of the Capitol Traction Co., of Washington, D. C.

In September, 1897, the main cable power station of the Capital Traction Co. was completely destroyed by fire, necessitating the rebuilding of the establishment or its replacement with an electrical system. The latter course was decided upon. The company owned a large building on the Chesapeake & Ohio canal, which had formerly been used for feed storage, etc., in the days or horse cars. This building was admirably situated for a power station on account of the proximity of the canal for coal carriage and water supply, and was adapted for that purpose by some minor alterations. The building was so long and narrow, however, that it was impossible to place the boilers and engines on either side of a central division wall in parallel rows, according to standard practice.

Steam is furnished by eight boilers of the Babcock & Wilcox type, of 350 HP. each, arranged in four batteries of two boilers each, and equipped with Roney mechanical stokers. The furnaces are connected to the steel stack by back flues of brick, which are supplied with dampers controlled by Locke damper regulators. The stack is 158 ft. high and 9 ft. in diameter.

The water after being filtered is sent through feed-water heaters connected to the main engines, where it is heated to from 90° to 120° F. It then passes to an auxiliary heater, where it is further heated by the exhaust from the stoker engines, pumps and other auxiliaries. Thence it goes directly into the feed line and into the boilers.

Coal is brought to the plant by canal during the greater part of the year. It is unloaded by a coal tower and carried by a conveyor to bins above the boiler room. Run-of-mine, semi-bituminous Cumberland coal is used and cost about $2 per ton in the boat and 10 cts. per ton is paid for handling. After being weighed, the coal is chuted to a crusher before passing to the bins.

The engine room contains five main units, each consisting of a Reynold-Corliss tandem-compound, 800-HP. condensing engine direct-connected to a General Electric generator. The engine cylinders are 20 and 40 ins. in diameter, with a 42-in. stroke, and the engines run at about 100 revolutions. The mains carry about 125 lbs. steam pressure. The exhaust from the high pressure cylinders passes through receivers fitted with live-steam reheating coils. From the low-pressure cylinders the steam is exhausted through Hartford horizontal feed-water heaters into Dean jet condensers. The receiver, feed-water heater and condenser for each engine are entirely independent of those of any other engine. A Best-Fox separator is placed in the main header, the drip from which is tapped into the blow-off connections from the boilers. Water for feed and condensing purposes is taken from the canal.

The object of the test was to find the efficiency end economy of the main plant as a whole, under ordinary working conditions, for the entire 24 hours. The first of the main units starts up each morning at about five o'clock, and the last shuts down at about half-past one o'clock the next morning. During this time the load on the system constantly varies, reaching a maximum between 8 and 9:30 a. m., and again between 4:30 and 6 p. m. Different combinations of the main units are used to meet these variations in load. Various auxiliary engines are also used at different times.

This great difference in load during the whole day must be met by the boilers and the steam supply must vary directly with the load. Two of the main units run until the time of shutting down and then stop almost simultaneously. The steam pressure must therefore be reduced as the time of closing the road approaches, and as the fires cannot be banked when using mechanical stokers, they must be burned very low at this time. Thus the conditions are seen to be anything but constant when the whole day is considered and the plant cannot be expected to show as high an efficiency as such a plant would undoubtedly give under a steady load.

The performance of the several parts of the plant is shown by the following summary of results.

Approximate Analysis of Coal.

Moisture	2.16%
Volatile matter	16.85%
Fixed carbon	72.23%
Ash	8.76%
Combustible, per cent. of coal	89.08%
B. T. U.s per lb. of coal	14,708
B. T. U.s per lb. of combustible	16,511
Dry coal burned per sq. ft. grate surface per hr.	11.4 lbs.
Equivalent evaporation (from and at 212° F.) per sq. ft. of heating surface per hour	1.9 "
Actual evaporation per lb. of coal	10.44 "
Equivalent evaporation per lb. of coal	12.37 "
Efficiency of boilers, including grates	72.67%
Average HP. per boiler	218.8
Percentage of feeder's rating developed	62.2%
Water rate of main engines	22.78 lbs.
Coal per I. HP. per hr.	2.18 "
Coal per electrical HP. per hr.	2.21 "
Cost of coal per ton in boiler-room	$2.10
Cost of coal to evaporate 1,000 lbs. of water	8.96 cts.
Cost of coal to evaporate 1,000 lbs. from and at 212° F.	8.48 "
Cost of coal per I. HP. per hour	0.204 "
Cost of coal per E. HP. per hour	0.207 "
Cost of coal per E. HP. per 3,000-hour year	$6.21

METHODS OF CHARGING FOR ELECTRIC POWER.

The accompanying graphical scale for selling electric power is rather novel, and, at the same time, it marks a step in the right direction. The consumer pays a portion of the charges due to the permanent investment, the amount being determined by the size of his motor, the argument being, obviously, that the size and cost of the generating and distributing equipment depend upon the total HP. of the motors installed, and the burden of that cost should be distributed uniformly

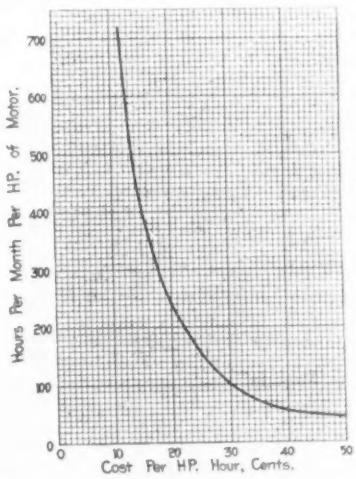


Diagram of Power Charges for Electrical Service, La Bella Mill, Water & Power Co., Denver, Colo.

to each motor unit. In addition to this he pays a certain amount per unit of energy used, the energy consumed being determined by the meter reading. In this way the total cost of power is made up of two parts—first, a fixed charge based upon the size of the motor, and, secondly, a charge for the energy used. It will thus be seen that the total cost of a horsepower hour is the less the more hours the motor is run at full load, and it is this that the curve is designed to show.

This curve was constructed by Mr. L. L. Sommers, Consulting Engineer to La Bella Mill, Water & Power Co., of Denver, Col., and we quote from a letter received from him in further explanation:

The power curve is based upon power delivered, and, hence, is independent of the power factor, the meters measuring only the power, and our estimates being based upon this. The chart is empirical to a certain extent. The general basis is that a motor used 12 hours should earn twice as much per hour used as a motor operated for 24 hours. Thus the fixed charge is twice as much for 12 hours as for 24, the energy charge being nearly the same per unit. On this basis a curve can easily be constructed consisting, first, of a fixed charge per hour which varies with the hours the motor is used, and is inversely proportional to these hours, and, second, an energy charge which is fixed at the actual cost of coal supplies. Owing to the fact that, when the motor operates for 12 hours, it is taxed double the fixed charge that it would be were it operated 24 hours, it makes a heavy charge for short periods of operation. As there is, in practice, a possibility of utilizing the energy elsewhere—that is, of using the energy of the day motor for lights at night—the curve can be modified to cover about the proportion of energy that will be doubly used. This feature is the empirical one, depending on the local conditions.

TWO PACIFIC MAIL STEAMERS are being built by the Newport News Shipbuilding & Dry-Dock Co., for service between San Francisco and Hong Kong. They will each be 575 ft. long over all; 63 ft. beam; 40 ft. deep; 18,400 tons displacement at 27 ft. draft; 12,000 tons gross tonnage; 18,000 I. HP. and 18 knots speed. They will have a bunker capacity of 2,500 tons of coal, and carry 150 cabin passengers and 1,200 steerage. Each ship will be driven by two quadruple expansion engines, with steam furnished by 6 double and 2 single ended Scotch boilers, with a working pressure of 200 lbs. The cargo capacity will be about 10,000 tons, with all the latest facilities for handling cargo.

PROPOSED PLANS FOR BRIDGES AND TUNNELS ACROSS THE EAST RIVER AT NEW YORK CITY.

The present year has been remarkable for the numerous costly schemes that have been brought forward looking to additional transit facilities across the East River. At the present time one bridge is under construction by the city and surveys and preliminary plans have been completed for two others. Complete surveys and general plans have been made by a private company for a double track railway tunnel; and appropriations have been requested, with a fair chance that they will be granted, for surveying the routes for two more double track tunnels to be built by the city. Altogether these various enterprises represent an aggregate expenditure of about $75,000,000 in round figures. We have discussed the need of these proposed new transit routes and their respective merits in our editorial columns, and in what follows will be found a brief outline of their origin and development.

At the present time, as most of our readers know, transit facilities across the East River comprise one bridge, the New York and Brooklyn, completed in 1884, and many lines of ferries. The work of construction is now well advanced on a second bridge, located about two miles north of the present structure. Both of these bridges are of the suspension type. The proposition to add two more bridges to these structures already provided for, was first definitely put before the public in December, 1898. So far as the public records show, the proposition originated with Mayor Van Wyck, who, it may also be stated here, has since devoted his personal attention to seeing it carried forward. The mayor's resolution advocating the new bridges fixed their location and character within certain narrow limits, and authorized the appropriation of $100,000 to be expended in making the necessary surveys and plans. It was passed without opposition by the Municipal Assembly. In obedience to the resolution, the Department of Bridges conducted surveys and drew up preliminary plans for a bridge crossing the river at Blackwell's Island at about 70th St., and also for a bridge crossing the river from the foot of Washington St., in Brooklyn, to Peck Slip, in Manhattan, or about a quarter of a mile above the present Brooklyn Bridge. These preliminary plans were approved by the Board of Public Improvements on Nov. 29, 1899, and on December 4, following, a resolution was offered by the Mayor at the meeting of the Board of Estimate and Apportionment requesting the Municipal Assembly to authorize the issue of bonds amounting to $1,000,000 for each bridge, the proceeds of which were to be employed toward constructing the foundations for the piers. Previous to this action, the Board of Estimate and Apportionment had passed a resolution asking for an appropriation of $100,000 to be employed in making soundings and borings for these foundations, and it may be noted at once that this appropriation was granted by the Assembly and approved by the Mayor on Dec. 19, 1899.

Upon the presentation of the resolution granting the $2,000,000, to the Board of Estimate and Apportionment on Dec. 4, the first serious opposition to the construction of the proposed bridges appeared within the city administration. As a member of the board, the City Comptroller, Mr. Bird S. Coler, presented an argument, accompanied by reports from expert engineers, in favor of constructing tunnels instead of the proposed bridges, and urged that the requested appropriation should not be granted, at least until an investigation had been made, respecting the relative advantages of tunnels and bridges for solving the problem before the administration. The Comptroller's opposition failed to defeat the resolution, which was passed over his veto and submitted to the Municipal Assembly. This setback to the tunnel movement was partly retrieved, however, at the meeting of the Board of Public Improvements on Dec. 6, when a resolution proposed at the instigation of the Comptroller, was passed, which requested the Municipal Assembly to authorize the appropriation of $75,000 to be employed in making preliminary plans and surveys for two East River tunnels. The locations proposed for these tunnels were from the foot of Whitehall St., in Manhattan, to Hamilton Ave., in Brooklyn, and from West 42d St., in Manhattan, directly across the river to some suitable point in Long Island City. Double track tunnels were called for in both locations.

To back up his opposition against the proposed bridge plans, and to support his plans for tunnels as a substitute, Comptroller Coler secured expert reports from Mr. Wm. B. Parsons, M. Am. Soc. C. E., Chief Engineer New York Rapid Transit Commission, and from Mr. J. Vipond Davies, M. Am. Soc. C. E., one of the engineers of the East River Gas Tunnel, and of the projected Long Island R. R. Tunnel. Summarized very briefly, these reports maintain the following general propositions: (1) Tunnels possess the important advantage of being cheaper to construct and maintain than bridges; (2) tunnels require no purchase of expensive real estate for approaches, as these can be located on city property underneath the streets; (3) as tunnels do not require the purchase of costly real estate they can be run anywhere, even directly across the city, and so connect with every intersecting transportation line; (4) the gradients on the approaches are descending in the case of tunnels, and ascending in the case of bridges, and trains can therefore be started more quickly and operated more economically in the former case; (5) tunnels can be built more quickly than bridges; they give a better foundation for railway trucks and permit higher speeds; they can be made perfectly dry and free from fog and weather conditions; (6) the material beneath the East River is rock or compact soil, which are especially suitable for tunnel construction; (7) several tunnels can be built for the cost of one bridge, and can be distributed at several different points along the river front, thus better accommodating the traffic.

The arguments offered by the engineers of the Department of Bridges against tunnels and in favor of bridges may be briefly summarized as follows: (1) Subaqueous tunnels, such as would be required under the East River, would be purely experimental, both in respect to the execution of the work and their operation; (2) it would be almost impossible to construct such a tunnel so as to render it dry; (3) it is practically impossible to locate a tunnel under the East River having a grade that would permit train traffic, and at the same time have a terminal at any reasonably accessible point on Manhattan Island; (4) to furnish the same traffic capacity as the New East River Bridge, would require six 15 ft. tunnels and two 28-ft. tunnels, which would cost more to construct than the bridge; (5) tunnels are wholly unfit for the use of teams and pedestrians.

As previously stated, the two resolutions, one to go ahead with the construction of bridges, and the other to make surveys and studies for two tunnels previous to proceeding with the bridge work, are now before the Municipal Assembly for consideration. The Assembly has referred both resolutions to the proper committees, and these committees are holding public hearings to hear arguments for and against each proposition. In a future issue we shall note the result of these hearings, and also such action as may be taken by the Assembly.

EXPERIMENTS UPON THE DURABILITY OF DIFFERENT METAL COATINGS IMMERSED IN WATER.

In our issue of July 28, 1898, we described the results of an experiment made to determine the durability of different coatings for metal when immersed in sea water. These tests were made at the Brooklyn Navy Yard, and comprised only a portion of an extensive series of experiments planned by Prof. A. H. Sabin, Assoc. M. Am. Soc. C. E., of Edward Smith & Co., the well-known paint manufacturers of New York city. The remaining tests were conducted at Lake Cochituate, near Boston, Mass., and at the Norfolk Navy Yard, at Norfolk, Va., and are described, together with those given in our issue of July 28, 1898, in a paper read by Prof. Sabin before the American Society of Civil Engineers on Dec. 20, 1899. The following is an abstract of the parts of Prof. Sabin's paper giving the conditions and conclusions of the tests:

Conditions of Tests.—One set of plates was exposed in salt water at the Brooklyn Navy Yard, another set was exposed under fresh water at Lake Cochituate, and a third set was exposed under salt water at the Norfolk Navy Yard. All the plates were placed in water during the last half of June, 1897. The Norfolk and Cochituate plates were removed from the water in July, 1899, after two years' exposure, but those in the New York waters were in cages suspended to a float which was accidentally sunk in July, 1898, and more than half of the plates were lost. The remaining plates were removed on July 21, 1898, after an immersion of exactly 13 months.

The plates were suspended in open cages or racks, and were in a horizontal position one above another, about 2 ins. apart. They fitted tightly in the racks, and each plate was supported at the four corners. The racks were suspended about 6 ft. below the surface of the water, but at Lake Cochituate they were laid on the bottom, which was hard, about 20 ft. below the surface, and the plates were vertical. Besides the plates lost at New York, one rack containing 25 plates was lost at Norfolk. It was suspended by two ⅝-in. galvanized iron chains, which rusted off. This gives some idea of the severity of the exposure. All the Boston plates were recovered.

In the salt-water tests it was found that barnacles and other organisms attached themselves to the lower sides of the plates. In the Norfolk Navy Yard the action of these was so severe as to destroy the paint on the under sides of all the plates, with the exception of those coated with the Sabin Pipe Coating, which did not seem to be affected, although oysters 4½ ins. in length were found growing on it. When these were removed the coating was found to be intact.

Such varnishes as are mentioned in this paper are made by melting, at a temperature of 700° to 900° F., certain resinous substances, such as Kauri, Manila and Zanzibar resins, and the asphaltic mineral known as gilsonite; 100 lbs. of resin is usually melted at once, and to this is then added a quantity of linseed oil, also hot, the amount of which varies according to the kind of varnish to be made. If 20 gallons of oil is used the product is called a 20-gall. varnish; if 30 gallons, it is a 30-gall. varnish, and so on. The mixture of resin and oil is then heated for some hours until combination occurs, and the product is then thinned with spirit of turpentine, which is regarded as a vehicle. Enamel paints are made by grinding pigments in these varnishes, exactly as oil paints are made by grinding the same pigments in linseed oil. Inasmuch as it has been believed that the process of baking adds to the durability of these coatings, in a few cases duplicate plates were prepared, one of which was baked and the other allowed to dry at the ordinary temperature.

The general scheme was to apply to a set of four plates a set of three varnishes, 20 Kauri, 30 Kauri and 40 Kauri, and pure raw linseed oil. Then, for another similar set, these same liquids were mixed, by grinding with white zinc; another set was prepared with white lead; another set with ultramarine blue; another set with graphite; and so on. This ought to show whether one pigment is better than another, and which vehicle is the best. Besides these, plates were painted with pure red lead in pure linseed oil, with two mixtures of red lead and white zinc, with purple oxide of iron (crocus) in oil, and with Prince's metallic oxide of iron, which is a very well-known pigment consisting of iron oxide mixed with various silicates, in oil. Besides these coatings of known composition, a number of popular and widely-known proprietary paints were tried. These oil paints and proprietary paints were presumed to afford a sort of standard by which the other coatings could be judged.

The plates used for the purpose were of uniform size, 12 × 20 ins.; part of them were aluminum and the remainder steel, about ⅛-in. in thickness. Since it is well known that aluminum is not acted on by fresh water, the aluminum plates were all put in the New York and Norfolk sets. Besides these regular sets of plates a cage containing 24 plates, part steel and part aluminum, which had in 1896 been exposed for six months in the New York yard, and are described in the author's paper in November, 1896, were again exposed with the New York set. All the plates, except those coated with Sabin Pipe Coating, which had two coats, received three full coats, well dried between coats. The red-lead paint used weighed about 35 lbs. to the gallon, and was put on with the plate in a horizontal position, on the top side of the plate. After the paint had set, the plate was turned over and the other side was painted. The steel plates

were all of the grade known as pickled and cold-rolled, and were cleaned with a steel wire brush. They were not pickled after they had left the steel mill, but their surfaces were perfectly clean and bright after being brushed.

Results. Tests.—In most cases, the protective coatings seem to begin to deteriorate on the surface, which becomes rough; then little blisters appear, which are caused by the separation of the last coat from those beneath; finally the undercoat blisters, in which case it is found, almost invariably, that rust has formed under the blister. If, however, the coating is porous—and this seems to be the case with the ordinary oil paints—the water reaches the metal and causes rust. This throws off the paint film, and the corrosion spreads rapidly in this way.

Protective coatings, such as are applied with a brush, are of three classes: (1) Pigment paints, in which the vehicle or liquid part is either linseed oil (or an inferior substitute) or varnish, and with this liquid portion is mixed mechanically a powdered solid, usually a mineral substance ground to a fine powder; (2) Red lead, which is a mixture of red lead and linseed oil, and which does not dry by oxidation as do other oil paints, but sets like a cement; and (3) Varnishes.

The linseed oil in ordinary oil paints dries by the absorption of oxygen to a tough leathery substance, but the film thus formed is soft and gummy, and is quite porous. Pigment is added to the oil for three reasons. It makes the liquid thicker and more viscous, thus enabling the operator to put on a thicker film; it makes a harder film, which will better resist abrasion; and the particles of pigment tend to fill up the pores of the film, thus rendering it more continuous.

Varnish forms a much more continuous (less porous) film than oil, hence it is better adapted for use in paint, and this is shown conspicuously by an examination of these tests, where the oil paints have failed, without exception, while the corresponding varnish paints are, in most cases, in good condition. The character of the pigment does not seem to have much influence. All the oil paint samples were so badly rusted that differentiation among them was impossible. It may be that an earlier inspection would have shown differences, but the present appearances of all these plates is so similar that it seems unlikely, and certainly the varnish paints do not show any great differences in the matter of the pigments, except that white zinc seems to be somewhat the best. The iron oxides, graphites and pulverized slate are all alike. The red lead, in the Boston and New York sets, is far better than any of the oil paints. The mixtures of red lead and white zinc are markedly inferior to red lead alone. In the Norfolk test, which was much more severe, the red lead had finally been quite destroyed. Deterioration in the case of red lead seems always to start from centers. In the Boston set, the red lead seemed to be in pretty good condition, but would probably not have lasted more than a year or so longer. It shows numerous rust spots. The blisters all start from the metal. But most of the varnish paints are much better than the red lead.

A study of the varnishes applied without pigment seems to show that in the fresh-water exposure the process of baking was, on the whole, of advantage, but not greatly so. In the salt water, the unbaked varnishes were better than the same varnishes baked; this agrees with the results recorded in 1896. The Manila varnishes are distinctly inferior to the Kauri and Zanzibar; the "Durable Metal Coating" is best of all. This is doubtless due, in a large degree, to the fact that this varnish, which is intended especialy for the protection of structural steel, is made with a heavy body, and the film is of greater thickness than is the case with varnishes intended for wood work. Its composition has also been very carefully studied and designed to secure great durability, which is of much less importance than other qualities in ordinary varnishes.

By far the best results, however, with the exceptions to be hereafter noted, were obtained from the best of the enamel paints. Here, also, the Manila varnishes are decidedly inferior, and, in the opinion of the author, these should be excluded hereafter from any such tests, although they make a much better comparative showing on wood.

In the enamel or varnish paints, those made with the more elastic varnishes (those containing the most oil) are decidedly the better. The extreme durability of these is well shown by the "1896" plates. These were first exposed to the air two or three months, then they were in the sea water six months, then exposed to the air nearly a year, then under water 13 months, and have since been exposed to the air over 16 months, making a total of four years, and they are still, to all intents, perfect. It is true that the air exposures have been indoors, but it was in a building adjacent to a railroad yard, where unprotected iron and even nickel steel is covered with deep rust in two or three months, and the air is often so acrid as to cause coughing. Two years' continuous immersion in fresh water has not injured some of these enamels, and two years in the excessively severe exposure at the Norfolk navy yard has left several of them in good condition, a few being practically uninjured.

It is generally true of all the better class of coatings that corrosion begins at the edges of the plate. In the case of aluminum plates, it seems evident to the author that some of these coatings, notably the "Spar varnish," and the "Durable Metal Coating," have been gradually thrown off by corrosion creeping from the edge, probably from some mechanical injury, under the varnish, a patch of which remains uninjured and apparently without deterioration on the middle of the plate. This fact should not be lost sight of in considering this matter, and is one of the points shown by an inspection of the plates, but not easily brought out in a description.

Undoubtedly, the most obvious and conspicuous, and the most instructive, fact, is the total and absolutely universal failure of linseed oil films, either alone or mixed with any of the numerous pigments which were tried. while the corresponding varnishes and enamel paints made with the same pigments are in fair to good condition. This confirms strikingly the opinion, long held by the author and many others of greater experience, that varnish films are much more impervious and resistant than any others. The exceptional cases to be noted are:

1. The "Sabine Pipe Coating," a baked enamel, which is so much superior to the others as to form a class by itself, and

2. The extraordinary showing made by pure shellac varnish in the Lake Cochituate test. Shellac varnish is simply a solution of shellac resin, which is chemically an acid substance, in alcohol.

There are many grades of shellac; the one used was what has for many years been known as "D. C." orange shellac, and it was dissolved in pure 97% grain alcohol. Being an acid substance, it is attacked and dissolved readily by the ammonia in the atmosphere. It is removed easily by soap and water. It has never been considered a durable varnish as ordinarily used on wood work, and it does not stand at all in the sea-water tests, but two years' exposure under 20 ft. of fresh water does not seem to have injured it sensibly. This may be a very serious matter, for, while in this regard it is no better than some other varnishes, such as "Durable Metal Coating," which cost much less money, shellac varnish has some important and exceedingly desirable qualities, which no other varnish has. For example, occasionally, we are confronted with the problem of repainting a section of large water pipe which can be spared from use only a few days. The interior of this pipe is damp. The best that can be done with it is to get out most of the visible water, but the cold surface of the metal will always be damp. No ordinary varnish will stick to such a surface, and corrosion will probably be set up at once; no ordinary varnish, of sufficient durability to be worth putting on, will dry in the limited time at our disposal. Now, shellac is dissolved in a vehicle which has an intense affinity for water, and it is highly probable that a thin film of dew will be instantly absorbed, and will certainly be removed, by the exaporation of the slightly diluted alcohol; and shellac, if applied in a thin coat, dries with the greatest rapidity. Three coats may be applied in eight hours. There is no unpleasant or dangerous odor, though ventilation should be secured, both on account of the risk of fire and because working in an atmosphere of alcoholic vapor produces intoxication. It certainly seems from this test as though we would be justified in using shellac varnish in such a case. It is expensive, of course, and it is very likely that the cheaper grades, which are found in ordinary use to be very much inferior in durability, would not be so efficient. In any case it would not be necessary to use it where the conditions are such that some equally good, but slower drying coating can be used.

The metal plates used in these tests were free from rust or scale, and showed in all cases the bright color of the metal. To prepare plates for a paint test, this is the only way which will give comparative results. The author is positive about this. It is sometimes said that we do not get our metal in this condition when we paint it, and therefore it is proper to make tests on somewhat rusty iron, or on iron with mill scale on it. In the first place, we ought to get the iron in that clean condition, and the author is not without hope of living to see the day when it will be done, in the case of permanent structures; and, secondly, he is satisfied, from many years' constant experience in such experiments conducted on a most extensive scale, that it is absolutely impossible to get uniform conditions with rusty metal. A dozen metal plates, even if cut from the same sheet, will not rust uniformly; one will throw off a scale and another will not. The mill scale on a plate will be almost entirely removed from part of a plate by passing it through bending rolls, while it will adhere firmly to another part of the same plate. If this plate had been cut up and used for tests, the paint on one piece would come off and on another would stay on, and the scale is always different on the two sides of a plate.

Exposure tests, such as these, are of much more importance than laboratory tests. The manufacturers of paints and varnishes, some of whom are probably the best experts in this matter, never depend on any but an exposure test. It is by no means impossible that rapid laboratory tests may yet be devised, but such crude ones as have been so far proposed are in most cases of little value. Such a test, for example, is that with caustic alkali. This is a substance unknown in nature, and no good paint will stand it, while a perfectly worthless paint might be made which would stand it very well. A nitric-acid test is of the same sort. It will simply burn up any organic substance, and some of the best linseed oil paints will yield to it most readily. It would hardly be regarded as a fair test of the comparative health of a dozen human beings to administer to each of them a couple of ounces of nitric acid and keep watch to see which lived longest, yet probably each could take a few drops of it per day without inconvenience. This is about what many of these so-called paint tests amount to. Some laboratory tests are of considerable value, but none is conclusive.

It has frequently been objected to these submarine tests that they are of value only as regards the same conditions, and there is some justice in such a criticism; but it is much weakened by the obvious fact that there is a practical agreement between the fresh-water and the sea-water tests. The latter were most severe, but in most cases the difference has been one of degree only. And in the rather large experience of the author and his associates, these tests seem to agree in general with aerial exposures, reasonable exception being made in the case of coatings intended expressly for marine or for aerial use.

Discussion.—The discussion which followed the reading of the paper consisted chiefly of explanations made by Professor Sabin in reply to questions respecting parts of the paper which were not fully understood. Mr. L. L. Buck, however, referred to a test recently made by him to determine the relative durability of various metal coatings applied to steel wire such as would be used in manufacturing suspension bridge cables. The test consisted in painting short lengths of No. 8 gage wire, bending these together in a bundle of seven wires, and suspending this bundle to a pile at a point midway between high and low water. Only one or two of the paints used withstood the test at all well, the one which stood best being a patented composition going by the name of "cable shield." Professor Sabin regarded a test similar to this, that is, one where the coatings were alternately covered and exposed by a tidal water, to be less severe than one in which the coatings were kept continually immersed. He also considered it objectionable on account of the abrasion to which the specimens were subjected from drift floating on the water surface. He pointed out that the ordinary coating of paint used was only two or three hundredths of an inch thick, and that it did not take much abrasion to wear it so that places were opened for the entrance of the sea-water to the metal.

PRINCIPLES AND CONDITIONS OF THE MOVEMENTS OF GROUND WATER.*

While a knowledge of the principles and conditions controlling the movement of underground water are all-important to the engineer of water supply, the literature upon this subject is scanty and the mass of that in existence is in German or French. For these reasons engineers are greatly indebted for the thorough investigations made by Prof. F. H. King, of Madison, Wis., and by Prof. C. S. Slichter, and to the U. S. Geological Survey for aiding in and publishing the results of these investigations. Space permits only a brief resume of some of the general considerations and results, and for details and tabulated statements the reader is referred to the work published by the U. S. Geological Survey.

In opening this subject, Prof. King remarks that the movement of moisture in the atmosphere is so rapid that it has been estimated that 6% of the land area of the globe receives more than 75 ins. of rainfal annually; 16% receives from 50 to 75 ins.; 25% from 25 to 50 ins.; over 30% from 10 to 25 ins.; while only 20% receives less than 10 ins. per year. In Japan, a fall of rain of 29.5 ins. in one day is recorded; and in India 39.5 ins. fell in 24 hours. Of this water falling on the land, one portion at once finds its way by surface flow into the drainage channels, another part evaporates where it fell, and a third portion enters the ground. The water that evaporates from the surface, to again fall upon it, maintains that moisture of the soil essential to plant life; and the salts gathered up by the water as it moves through the soil and rock go with it to the sea, to be left there in the process of evaporation and the water coming from the sea to the land is fresh and pure.

The amount of water stored in the soil varies. Sands and sandstones lying below drainage outlets may contain as much as 38% of their volume of water; and the Dakota sandstone, for example, stretching from the foothills of the Rocky Mountains eastward beneath the plains of the two Dakotas, Nebraska and Kansas, may be likened to a submerged inland sea; for wherever this formation lies beneath the zone of saturation it carries from 15 to 38 ft. of water for every 100 ft. in thickness of the sandstone itself. The Potsdam

*Principles and Conditions of the Movements of Ground Water, by Franklin Hiram King. With a Theoretical investigation of the Motion of Ground Waters, by Charles Sumner Slichter. Extract from 19th Annual Report of U. S. Geological Survey, Washington, D. C.

sandstone, in southern Minnesota and Wisconsin, in Illinois and Iowa, has a measured thickness of 500 to 1,000 ft., all lying beneath the surface of saturation. And in this great bed is stored away a quantity of water equal to 10 to 38 ft. in depth for each 100 ft. of thickness; and 500 ft. of this formation may store the equivalent of an inland submerged sea with a mean depth of 50 to 190 ft. of water.

The soil, sand, gravel and clay also contain a surprisingly large volume of water, outside of arid regions. A saturated sand carries from 20 to 22% of its dry weight of water; and the soils and clays range from these values to 40 and even 50% of their dry weights. As a cubic foot of dry sand weighs from 102 to 110 lbs., and the soils, clays and gravels range between this and 79 lbs., the quantitative volume of water thus stored is readily estimated. Tables given show that the storage capacity of soil, in round numbers, is at the rate of 40 ft. of water on the level for every 100 ft. of soil. Where soil does not lie below the plane of saturation it usually contains 75% of the amount required for full saturation; except during dry times in a surface layer 1 to 5 ft. thick. The water stored above the plane of saturation will vary from about 4% of the dry weight, for coarse mixed sands, to 32% in clays of fine texture.

All other rocks than sandstone contain more or less water, in the interstices of the rock itself or in fissures formed in them. Even compact and close marble was found to absorb 0.23% of its weight in water, equivalent to 30 ft. of water in a rock column 5,000 ft. high. There are many reasons for believing that water penetrates the fissures of the earth crust to depths even exceeding 10,000 ft.; and if the water so enclosed formed only 1% of the weight of the material, with a specific gravity of 2.65, the amount of this enclosed water would be sufficient to form an envelope 265 ft. thick.

The water of the ocean and of the atmosphere is never at rest, and the same is true of the water under the surface. While these motions are numerous, extended and very complex, they may be brought under the three general heads—of gravitational, thermal and capillary movements. Of the first, seepage is by far the most important; it begins where the water enters the soil and ends where it again escapes into passages larger than capillary, or above the surface of the solid crust. The chief motive power is the hydrostatic pressure of the water itself, and this is intensified or reduced in various ways. Thus, a low barometric depression across a section of country is always associated with a more rapid discharge from springs, flowing wells, etc. Diurnal changes in soil temperature, in mid and late summer, and crust deformation and rock consolidation also have an influence on flow. When sediments are laid down on the borders of the ocean or on the bottom of inland seas quantities of water varying from 25 to 50% of the volume of sediment are locked up, according to the pore space in the sediment. When fine sediment overlies coarser materials, there is a tendency for a part of the entangled water to escape downward, and there is a compression or settlement in the upper layers.

The movements due to consolidation are enormous. It has been estimated that when the rock materials were first laid down in the Appalachian region the pore space containing water could hardly have been less than 33%, so that at one time they have contained in the aggregate not less than 1,200 ft. of water. But most of the rocks in this region have been greatly consolidated,, highly metamorphosed and crystallized, so that in much of it the pore space is less than 1%. Even if we suppose the average pore space of the Paleozoic rocks to be as high as 25%, and that this is still occupied by water, the displacement of water would be equivalent to a depression of 3,600 ft. for the whole series. These large volumes of water thus displaced must of necessity have reappeared at the surface in one place or another, and there must be an underflow of the sedimentary water from beneath the ocean towards the land; and this driving out of the extremely mobile water to make room for subsidence is one of the great gravitational movements of underground water.

The thermal movements of ground water belong to two classe; one resulting from direct expansion and contraction due to changes of temperature; the other represented by the phenomena of diffusion, osmosis and solution. When, during the process of subsidence, water-bearing sediments are carried downward several thousand feet, there is a large increase in volume by expansion due to rise in temperature; and, as this increase in volume is a measure of displacement, a flow of water in some direction is the result, with this movement facilitated by the fact that the internal friction is less in hot water than in cold. Poiseuille found that water at a temperature of 45° C. flowed 2.5 times as fast, under otherwise like conditions, as water at 5°C. The growth of grains and filling of pore space also displace water. Each sand grain is surrounded by a film of water that is stationary, except under very high pressure or very rapid flow; and in this film of stationary water the growth of the old sand grain takes place. and that interlocking follows which first converts a friable sandstone into a good building stone, and finally into a hard and impervious quartzite almost devoid of pores of any kind. The material in solution in the film of water is deposited, and then the energy of diffusion forces a new supply out of the moving current into the stationary film, and the consolidation of the mass goes forward. On the other hand, if there is a change in the character of the current passing the stationary film, and the moving water is less saturated than that of the film, solution may be set up and the pore space of the rock increased. This latter condition is everywhere maintained in humid soils, where the frequent fall of fresh water maintains a nearly constant solution of the soil grains and a leeching away of the dissolved products.

The final or nearly complete consolidation of 50,000 sq. miles of sediment 1,000 ft. deep, having a pore space of 33% filled with water, involves the actual transfer to a different region of the equivalent of a sheet of water 50,000 sq. miles in area and 300 ft. deep. And this amount is over and above the volume of gravitational flow required to transport the materials held in solution necessary to fill the voids represented by this sheet of displaced water. Mr. T. M. Read has estimated that the Mississippi River carries annually to the sea 150,000,000 tons of rock material held in solution, equivalent to 1,848,000,000 cu. ft. of solid rock having a specific gravity of 2.6. But with this degree of saturation it would require the volume of the Mississippi in continuous flow for more than 60,000 years to make the fill above referred to, supposing all the solids in solution were laid down. It is evident that these movements have been both great and long continued to produce the known deposits of sandstones, limestones and shales; even admitting that mechanical compression and flowage may have been at work in metamorphic regions.

The capillary movements of ground water are mostly confined to the superficial deposits of land areas; indeed, it may be said that they are almost exclusively limited to the unconsolidated soils lying above the surface of saturation. There can be no capillary movements in soils or rocks where the pore spaces are already filled with water. This capillary movement in ground water takes place in directions leading away from pore spaces wholly or partly filled with water, and towards those which are entirely empty or less filled than the other. It may take place upward, downward or laterally. The current passes downward in rains; ascend as the surface becomes drier, and passes towards roots from all sides in any soil-zone.

The rate of capillary movement varies with the distance the water must be raised and the pore space through which it must move. Where the movement is vertically upward through a distance of 1 ft. experiment shows that the ate for fine sand was 2.37 lbs. per sq. ft. per day of 24 hours; when the lift was increased to 2 ft. the movement was 2.07 lbs., at 3 ft.; 1,23 lbs.; and at 4 ft. only 0.91 lbs. per sq. ft. With medium clay loam, the movement was 2.05 lbs. for a lift of 1 ft.; 1.62 lbs. for 2 ft.; 1 lb. for 3 ft., and 0.9 lbs. for 4 ft. lift. No sufficiently exact data relating to field conditions are as yet available to show through what distances vertical capillary movements of water take place; but observations show that it is quite rapid at 4 ft.; so rapid that if maintained through the year it would deliver at the surface the equivalent of 63.85 ins. of water. This would almost prevent any part of the rainfall sinking deeply below the surface over much the larger part of the United States. But it does bring water to the surface or to the roots of plants, to be lost by evaporation, and in so much diminishes the volume of streams.

The percentage of precipitation penetrating the soil has been carefully studied by Mr. F. H. Newell, Hydrographer to the U. S. Geological Survey. He says that the mean annual run-off exceeds 20 ins. in Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, the Virginias, the Carolinas, Florida, Georgia, Alabama, Louisiana, Mississippi, Tennessee and Kentucky, together with the southern portions of Ohio, Illinois, Indiana, most of Arkansas, and a small part of Eastern Texas and Indian Territory. Throughout this region the annual rainfall ranges from 40 to 60 ins., reaching 60 to 70 ins. in a few comparatively small areas. This makes the run-off about 50% of the total precipitation. In all of Wisconsin and Michigan and parts of Ohio, Indiana, Missouri, Indian Territory, Texas, Iowa and Minnesota, Mr. Newell places the run-off at 10 to 20 ins., with a mean annual rainfall of 28 to 42 ins.; this makes the run-off 36 to 47% of the total rainfall. But in a narrow strip extending nearly north and south across the central portion of the United States, and taking in parts of Minnesota, Iowa and the Dakotas, and central Texas, the run-off is 5 to 10 ins. with a rainfall of 20 to 30 ins. Here the percentage relation is 25 to 33⅓. West of the last named region, in Western Washington, Oregon, and the mountainous parts of California, the run-off is 5 ins. to none; but bordering on this to the east is another section where the run-off is 2 to 5 ins.

It thus appears that in the more level districts of the United States, with a rainfall ranging from 10 to 70 ins., from one-fifth to one-half of the water falling as rain or snow finds its way into the streams; but by far the larger portion of this water has penetrated the soil to the ground water level and has emerged again. The water of rivers that does not take this course through the soil and rock is: (1) That which falls directly into water courses as rain or snow; equivalent in volume of total rainfall to the ratio between the superficial area of such lakes and streams and the total area of the region drained. (2) That which falls in heavy showers near water courses and on slopes too steep to permit penetration into the soil in the time allowed. (3) The heavy snows which melt rapidly on steep slopes near drainage channels. The percentage of these three forms of run-off is not known, but it is certainly smaller than a first judgment without reflection would be likely to place it; and it may be laid down as a broad proposition that nearly all the water of streams and small lakes is due to slow and constant seepage from the soil.

The water which enters the soil in excess of capillary saturation moves directly downward until it reaches the ground water surface; it raises that level and augments the pressure, and as difference in level is always associated with topographic forms, as soon as the pressure is sufficient the water is forced to flow through the soil and rock to the nearest existing drainage outlet. Contrary to a common belief, the level of water in rivers and lakes is no indication of the level of standing water in the ground. As a rule, the water of brooks and other streams lies below the level of the ground water, and the latter has a slope ruled by topograhpic conditions, as is shown by diagrams and tables in the original report of Prof. King. The flow of water, oil, and oil and water through wire gauze, perforated disks, various sandstones, sand, etc., was elaborately experimented upon and the details and methods are fully set forth in the report. A valuable table is given, showing the observed pore space in soil and rock; from which it appears to be generally true that well-rounded grains of nearly uniform diameter tend to give a pore-space lying between 32 and 40%; the mean theoretical pore-space for spherical

grains of a single size was found to be 36,795%. An entirely new method of determining the diameter of sand and soil grains was invented and used.

The experimental work that can not profitably be generalized here, includes the effect of size of grain on rate of flow, the flow of water through sand, seepage experiments, rate of lateral flow through sand, reduction of ground water pressure and interference of two wells.

One of the practical problems studied was the supply of water, or rate of flow into wells. Numerous examples are given; but the general fact was evolved that the capacity of the well is increased to a high degree the more the water is lowered in the well; and the well driller should see that the bottom of his well is sufficiently below the level of the ground-water to permit considerable lowering of the water; and the pumpman should see to it that the cylinder of the pump is so placed as to make it possible to utilize the full depth of the well. Another problem submitted was—with a well sunk 100 ft. into 200 ft. of water-bearing rock, with a pore-space of 32% and effective size of rock grain 0.25 mm., what will be the flow with pipes of 2.6 and 12 ins. diameter. Prof. Slichter found that the capacity of these three wells would be 31.90, 36.94 and 41.45 cu. ft. per min. Thus, the 6-in. well discharges only 15.8% more than the 2-in. well, while the 12-in. well discharges only 26.07% more. Those who assume that the flow through such pipes increases with the square of the diameter do not take into consideration the influence of the sand itself on the rate of flow into the well. If a given water-bearing bed can permit a flow of only 2 cu. ft. per min. into a well 12 ins. diameter, a 2-in. well will easily handle nearly all this water, as it will be able to collect 1,626 cu. ft. per min. Where the pressure of a flowing well is strong and the well deep, the laws governing the discharge of water through pipes come into play, and a too small casing may greatly reduce the amount of really available water.

As wells of considerable diameter are sometimes dug for the convenience of placing and working irrigation pumps, and to act in part as storage reservoirs in towns, a third problem related to the flow in a well 20 ft. diameter sunk 22 ft. into a water-bearing sandstone, when the well is lowered 20 ft. The solution gives as the amount supplied 46.12 cu. ft. per min.; or 1.25 times that of a 6-in. well sunk 100 ft. in the same rock. In this same 20-ft. well, one, two and three 6-in. wells were supposed to be sunk to the full depth of the 200 ft. of water-bearing rock, with the following results:

	Cu. ft. per min.
20-ft. well open, alone	46.12
" with one 6-in. well	110.2
" " two 6-in. wells 5 ft. apart	125.2
" " two 6-in. wells 10 ft. apart	130.1
" " three 6-in. wells 5 ft. apart	136.6
" " three 6-in. wells 10 ft. apart	142.3

Prof. Slichter further concludes that if the wells were placed in a straight line 10 ft. apart, the middle well woud flow 4% less than the end ones; if 5 ft. apart, 7% less.

Mr. Newell, as the result of his investigation, says that generally the flow into a well along the bedding planes, or planes of stratification, is much more rapid than when the flow takes place across them, as must be true when the water approaches the well from below. Where beds of coarse and fine-grained material alternate, the largest volume of water will naturally approach through the former, both because it is coarser grained, and because the reduction of pressure will be greater and farther reaching in the coarse stuff. This fact points out the importance of stopping the well in the coarse material; though it is true that the current leading from finer material may in time reduce the pore-spaces and decrease the flow.

AN UNUSUAL METHOD OF TRANSMITTING POWER.

The city of Columbus, Ohio, operates its own water-works, and, also, does its own street lighting. Recently three arc machines, of 100-light capacity each, were installed in the building containing the pumping plant, and the novel plan has been adopted of driving these dynamos by impulse water wheels supplied with water from the mains. As a direct-pressure system of water supply is in use, the power to drive the dynamos is really furnished by the pumping engine.

It may be of interest to make a rough comparison of this method of operating, and the ordinary method of driving the dynamos by a compound engine, as respects economy. Of course the location of the plant in the pumping station, and the use of the steam from the water-works boilers at a time when the water consumption is small, as it is during nearly all the hours of street lighting, are excellent features; but they could have been equally well secured had a special steam engine been installed to drive the dynamos. By using shaft clutches, the three dynamos could have been driven direct from one engine with only one belt transmission.

The advantage of the plan adopted is that the first cost of the water wheels is much less than the cost of a steam engine of equal power. The advantage in operating economy, however, would lie with the engine, as may be easily seen. The pumping engines in use in the Columbus station will probably average very little greater economy in foot-pounds of work actually delivered in water under pressure forced into the mains than could be secured from a first-class compound condensing high-speed engine suitable for driving arc dynamos. This may be disputed at first thought in view of the known high economy of steam pumping engines, and the low economy of electric lighting engines working under a variable load. It must be remembered, however, that the comparison is not made on the basis of indicated power, but of delivered power, and the loss in the water end of the pumping engine must be taken into account. Also, the arc light circuit furnishes a steady load which is favorable to high economy in the steam engine.

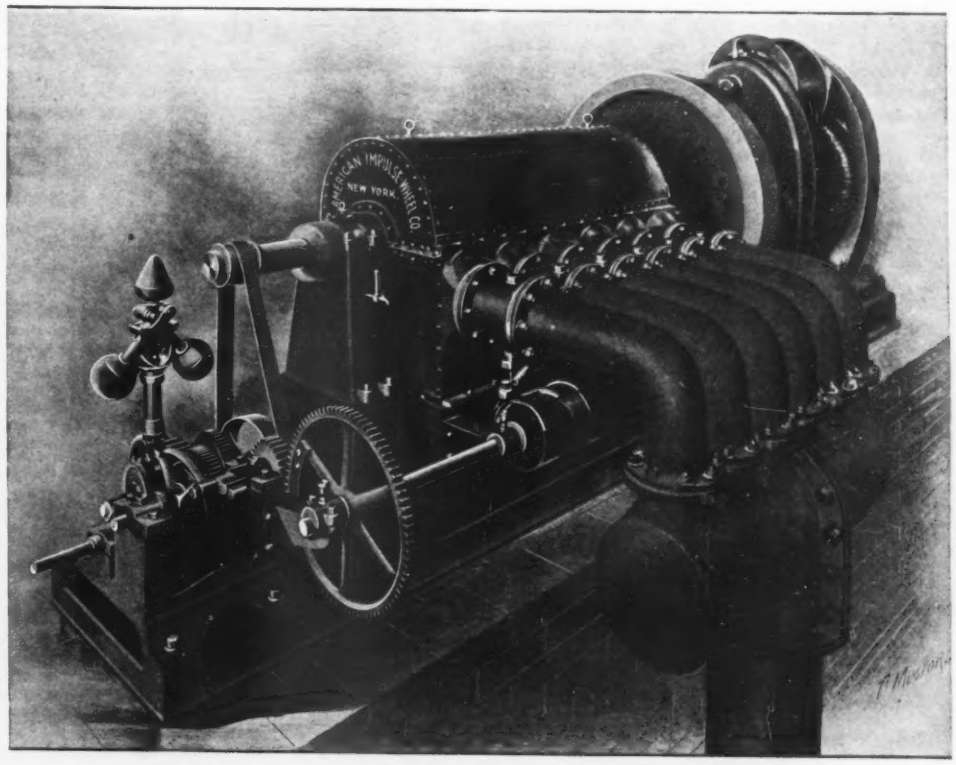
Assuming, then, that the steam required was the same to deliver a horse-power in the shape of water under pressure, or as turning moment on the engine shaft, we have in the case of the water wheel transmission to the dynamos an efficiency of probably 75%. For the belt transmission from the engine to the dynamos we have an efficiency of probably 95%. Thus if these assumptions are fair ones, there would be 20% advantage in the use of the independent steam engine so far as fuel economy is concerned. Whether this saving in fuel would pay the interest and depreciation on the extra cost of the steam engine over the water wheel is a matter depending so much on local conditions that we need not attempt its solution. It is fair to say, also, that there may be other local circumstances influencing the choice of this peculiar system of which we were not informed.

Desiring further information we addressed a letter of inquiry to one of the officials of the city and were favored with the following reply from Mr. Louis B. Kauffman, Director of Public Improvements:

> Yours, addressed to John T. Morris, Supt. of Lights, has been referred to me for answer. I have seen the statement with regard to this matter made by the "Electrical World and Engineer." As stated by the above mentioned paper, the wheels were put in by my predecessor. Actual experience with them proves that, situated as we are, the plan is a very expensive one, much energy being lost by repeated conversions. The plant, as it now stands, is a matter of mere temporary expediency, and when the city's contract with outside companies expires they will undoubtedly be discontinued, from the fact that it costs almost three times as much to produce the lights by this plan, as it costs by the more direct methods.

The water wheels installed, which are shown in the accompanying illustrations, were built by the American Impulse Wheel Co., of New York city, and have some novel features in their design.

The dynamos are designed to run at 650 r. p. m. At 80 lbs. pressure in the water mains this required a wheel only 18 ins. in diameter, and, in order to obtain 110 HP. at each shaft, 18 nozzles were found necessary. This was arranged by placing six runners on the shaft with three nozzles to a runner. The economical method of governing an impulse wheel is, of course, by the use of a contracting nozzle. To introduce so many contracting nozzles in the plant, however, would have been both expensive and complicated. It was, therefore, decided to use butterfly regulating valves, which are actuated by cams on a shaft controlled by the governor, as is shown in the illustration. These are so arranged that the governor shuts off one nozzle after another as the load on the wheel decreases, and reverses the operation when it increases. In this way a high efficiency is secured even under variable loads. The high speed rendered the use of a cast-iron balance wheel undesirable, and a built-up wheel was made by shrinking a steel rim on a cast-iron web. We are indebted to the American Impulse Wheel Co. for the illustration of the plant herewith presented.



VIEW OF IMPULSE WATER-WHEELS DIRECT-CONNECTED TO ARC DYNAMO IN WATER-WORKS PUMPING STATION, COLUMBUS, O.

The Governor Operates the Cam Shaft Controlling Butterfly Valves in the Supply Pipes.

Built by the American Impulse Wheel Co., New York City.

A NEW GRAVITY CONCRETE MIXER.

A new concrete mixer, working by gravity alone and without any machinery, has been devised by Lieut. P. C. Hains, Jr., U. S. A.,and Mr. Charles R. Weaver, and has been successfully used on government fortification work. It is exceedingly simple in construction and operation, as will be seen by reference to the accompanying cuts.

It is made up of a series of hoppers, three or four in number, and arranged one above the other, as shown. These hoppers are closed at the bottom by suitable gates, capable of being rapidly closed or opened by hand. The top-hopper is charged with the cement, sand and broken stone, in proper proportion, and in the sequence named; and these proportions are indicated by small battens on the inside of the hopper. The measured quantity of water, taken from a barrel or other reservoir, is then sprayed over the top of the whole, thoroughly wetting the stone and sand, but held from leaking through by the cement powder, which acts as a dam.

As soon as the spraying is completed, the gate of the top-hopper is suddenly opened and the mass falls to the next hopper, striking a baffle-cone on its way. As the stone is the heaviest material, it forces itself through the wet sand and the dry cement, forming a crater-like hole which rapidly widens as the stone from the sides rolls down. The result is, that by the time the stone reaches the second hopper it is very thoroughly coated with sand and cement; and by repeating this falling process twice, the whole mass is found to be so thoroughly rubbed and ground together that the resulting concrete is superior to the average make in its homogeneity and thoroughness of mixture.

A storage bin for sand and broken stone, placed just above the mixing hopper, adds to the rapidity of the process; while the cement can be dumped in by hand from barrels or bags.

The advantages claimed for this device are the following: Accurate gaging of the several ingredients; thorough incorporation of these ingredients; economy in first cost of the machine and its operation; ease of transportation and rapidity of mixing. It has been used with success in the Rock Point fortification work, in Baltimore harbor, where the best record was 63 cu. yds. of concrete mixed and placed in the work in one hour, the concrete being delivered in 42 batches of 1½ cu. yds. each. Where concrete is to be made in large quantities, the advantage of this rapid mixing and delivery is apparent, and of the utmost importance. The New York agent for this mixer is Mr. T. Jenkins Hains, No. 42 Bay 28th St., Bensonhurst, N. Y. The apparatus is covered by U. S. Patent No. 633,313, issued Sept 19, 1899.

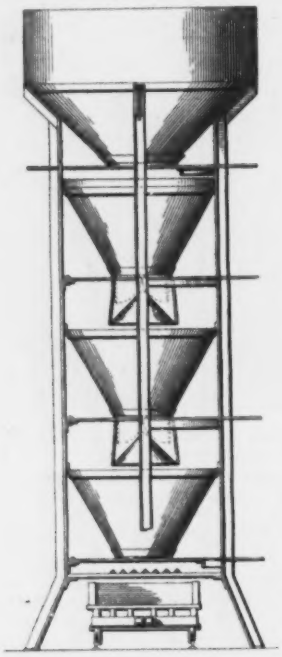


Fig. 1.—General Elevation of Gravity Concrete Mixer.

Lieut. P. C. Hains, Jr., and Chas. R. Weaver, Inventors.

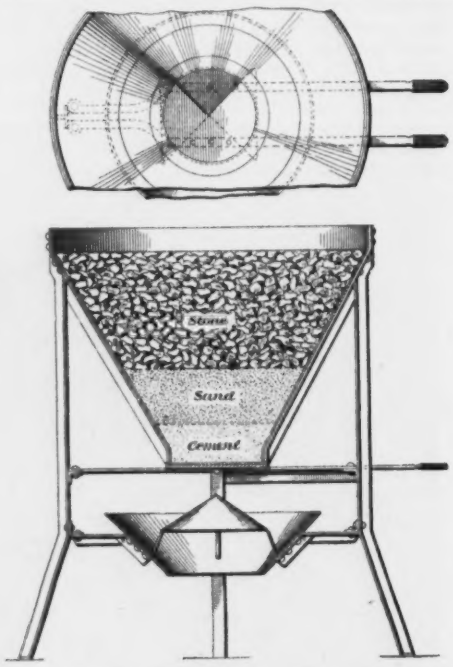


Fig. 2.—Section Through Top Hopper of Gravity Concrete Mixer.

BOOK REVIEWS.

DIE STRASSENBRUECKE UBER DIE NORDER-ELDE BEI HAMBURG.—C. O. Gelm, Abtheilungs Ingenieur ir. Hamburg und H. Engels, —— Prof. A. D. Techn. Hoschschule in Braunschweig. Berlin: Ernst & Korn. Boards, 12½ x 18 ins.; pp. 29; illustrated.

This is a very complete and fully illustrated description of the highway bridge built across the North Elbe River at Hamburg in 1884-7.

THE CONSTRUCTION OF ROADS AND STREETS, with Historical Sketch of the Development of the Art of Road-Making.—By William H. Maxwell, C. E., Assistant Engineer and Surveyor, Leyton. London: The St. Bride Press., Ltd., 24 Bridge Lane. Boards; 6¾ x 4¼ ins.; pp. 260; illustrated. $1.30.

The author presents a very complete resume of the English practice in road building and street construction. He goes into the details of road location and construction; character of materials; calculation of quantities, and the various methods or systems now in use. In this connection the author calls attention to the non-use of brick paving for city or town streets in England, and suggests that more attention be paid to the production of proper brick for this use. While the work is avowedly a compilation from many sources, it is useful as a compendium of British methods of road construction and maintenance at the present day.

INDICE DEL COMERCIO AMERICANO.—Directorio Descryptivo y Clasificado de los Miembros de la Asociacion Nacional de Manufactureros de los Estados Unidos. Arreglado para conveniencа de los compradores extranjeros. Philadelphia: National Association of Manufacturers. Cloth; 8¾ x 6 ins.; pp. 362.

This Spanish edition of the American Trade Index, with an edition of 5,000 copies, is now being sent out to merchants in Spanish speaking countries, and supplements an edition of 5,000 copies in English already gratuitously distributed among the English speaking colonies. It follows the plan and arrangement of the English copy and places in the hands of prospective foreign buyers an alphebetical and descriptive directory of American manufacturers, and also classifies in another part the products of these factories. A third part gives the registered cable addresses of these firms. It is a very practical way of doing missionary work for the extension of American commerce, and it is understood that the results are already very gratifying to the Association of Manufacturers.

LE MOIS SCIENTIFIQUE ET INDUSTRIEL.—Revue Internationale d'information, Paris, 55 Boulevard des Batignolles. 9½ x 6¼ ins.; averaging pp. 88; illustrated. Issued monthly, at 12 francs per year in Paris, and 20 francs to foreign countries.

To attempt to embody in a monthly periodical a resume of all that is interesting and useful to the scientific and industrial world in current technical literature is a task of very large dimensions; for it means a careful study of, and judicious selection from, an enormous mass of material published in many countries and in many languages. This is, however, the purpose of "Le Mois Scientifique et Industriel," and, what is more, the editors are performing their task with a fair degree of judgment and success. The material used is well classified, the best source of information is stated, and enough matter is given to indicate the scope and purpose of the article, together with illustrations when necessary. As yet, the exchange list is somewhat limited, and some prominent English and European technical papers are missing in the material used; but this is a matter that will probably be remedied in later issues.

THE STEREOPTICON METHOD OF EXAMINING AND INSTRUCTING RAILWAY EMPLOYEES.—By W. J. Murphy, Superintendent, Cincinnati; New Orleans & Texas Pacific Ry. Lexington, Ky.: B. E. King & Co. Cloth, 4¼ x 6 ins.; pp. 54; illustrated. Price 60 cts.

This little book describes the significance of railway signals and train signals, methods of effecting road repairs of engines, etc., and has examples of questions to be used in examining employees. It is illustrated by a number of half-tone engravings of signals, broken-down engines, etc., the former having the signal blades and glasses appropriately colored, from which we notice that this road uses yellow, with a black stripe for the running face of semaphores. Particulars of the Murphy system of eyesight tests are also given. In instructing the men, views similar to these shown in the book are thrown upon the screen, and by thus seeing the familiar signals on the road, they are more interested and more easily absorb the information given as to the positions and significance of the signals. The same system is employed for the eyesight test. The book is in use at the School of Mechanical Engineering of the State College of Kentucky, and has also been approved by Prof. J. H. Smart, of Purdue University, for the use of teachers of railway mechanical engineering.

LECONS SUR L'ELECTRICITE.—Par Eric Gerard, Directeur de l'Institut Electrotechnique Montifiore. 2d vol. of the 6th edition, revised and greatly enlarged. Paris: Gauthier-Villars et Fils. Paper, uncut edges; 6½ x 10 ins.; pp. 791; 387 illustrations; 12 francs.

There is no better illustration of the interest with which this book has been received than the fact that it has run through six editions in a few years. Moreover, this has made it possible to keep the book up to date. The first volume, in which the theory of electricity and magnetism is treated, was reviewed in Engineering News for July 20, 1899. The second volume, now before us, takes up the industrial applications of electricity as a producer of light, heat, motion and chemical action, opening with a description of the methods of distribution by which electric energy is transferred from the generator to the apparatus in which it is used. Special attention is given to the calculation of the fall of pressure upon alternating current lines. Electric traction is considered at length, and the illustrations show some of the latest American practice. A chapter is devoted to the subject of wireless telegraphy and photometry, electro-chemistry and electrometallurgy are also treated quite fully. The book derives its chief value from Professor Gerard's lucid manner of treating the theoretical aspects of the subject.

PRINCIPLES AND CONDITIONS OF THE MOVEMENTS OF GROUND WATER.—By Franklin Hiram King. Theoretical Investigation of the Motion of Ground Waters. By Charles Sumner Slichter. Extract from 19th Annual Report U. S. Geological Survey, 1897-98, Charles D. Walcott, Director. Washington, D. C. Paper; 11½ x 7¾ ins.; pp. 318; illustrated.

This is an important contribution to a subject upon which there is very little previous English literature; for, though ground water is being continually utilized as a source of water supply, in the great majority of cases, the controlling principles of its movement are matters of mere guesswork. The amount of water stored in various rocks and soils, the rate of seepage and flow, effect of crust deformation on the movement of water, capillary movements, effects of the size of sand grains on the rate of flow, lateral flow of water, rate of flow into wells and the interference of neighboring wells and the capacity of wells are some of the main heads of the very thorough investigation for which the engineering profession is indebted to Prof. F. H. King, of Madison, Wis. This investigation was proposed in 1896 by Mr. F. H. Newell, Hydrographer of the U. S. Geological Survey, and the Department of the Interior gave financial assistance to the undertaking. Prof. Slichter, whose theoretical and mathematical discussion of the motion of ground water accompanies this report, also gave his services to the solution of the 17 definite problems which the investigators proposed to work out. The results arrived at were deduced from experiments made with specially devised apparatus and by observations of the actual operation of driven and other wells and carefully constructed seepage tanks. It is impossible in the space available to go into details of this investigation and we must therefore advise those interested to study the report for themselves. The theoretical discussion of Prof. Slichter covers the laws of the rectilinear flow of water through a soil; the general law of the flow of ground water and its horizontal and vertical motion; flow of artesian wells and their mutual interference, and the application and illustration of the formulas deduced. He also appends an extended bibliography of papers relating in any way to this subject, nearly all of which are in German and French.

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